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Imitation of Intentional and Accidental Actions by Children with Autism

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Abstract To determine whether children with autism (CWA) would selectively imitate intentional, as opposed to accidental actions, an experimenter demonstrated either an ''intentional'' and an ''accidental'' action or two ''intentional'' actions on the same toy [Carpenter, Akhtar, & Tomasello (1998a) *Infant Behavior and Development*, *21*, 315–330]. CWA tended to imitate the experimenter exactly. Children with developmental delay and older typically developing children (TD) reproduced only the intentional action as often as they imitated the experimenter exactly. Younger TD mostly produced only the intentional action. It is concluded that, contrary to comparison groups, the CWA did not show an appreciation of the model's intentions. Results are discussed in terms of theories of social cognition.

Keywords Imitation · Intentionality · Joint attention · Social cognition

Introduction

Lack of social-communicative behaviours are amongst the earliest and most obvious signs of autism (Bernabei, Camaioni, & Levi, 1998; Osterling & Dawson, 1994; Osterling, Dawson, & Munson, 2002; Werner, Dawson, Osterling, & Dinno, 2000; Wetherby et al., 2004; Wetherby, Prizant, & Hutchinson, 1998; Woods & Wetherby, 2003). Indeed, children with autism (CWA) engage in relatively little joint attention (sharing attention with another person to an outside entity) and have difficulty understanding others' mental states (Baron-Cohen, 1989, 1995, 2001; Charman et al., 1997; Leekman, Baron-Cohen, Perrett, Milders, & Brown, 1997; Mundy, Sigman, & Kasari, 1990). Tomasello and colleagues have suggested that the ability to understand others as intentional beings with psychological relations to the outside world is what underlies each of the above-mentioned skills (Carpenter, Nagell, & Tomasello, 1998b; Tomasello, 1995, 1999). If one accepts that understanding of intentions developmentally predates, and is responsible for, the later understanding of others' attentional and mental states, then it becomes important to ask whether CWA have as much difficulty understanding the former as the latter.

Surprisingly, little research has been done on CWA's understanding of intentions and what has been done has not supported a clear deficit in understanding others' intentions. For example, Russell and Hill (2001) asked school-aged CWA (mean ages nine to 11 years) to report on their own and others' intended actions in a series of tasks where the outcome of the task was manipulated by the experimenter. They found that CWA performed as well as controls in reporting on their own and others' intentions (but see Phillips, Baron-Cohen, & Rutter, 1998 for differing results). In a study reported by Aldridge, Stone, Sweeney, and Bower (2000), 2–4 year-olds with autism were found to imitate intended actions on objects, even though the model never completed the intended act. Their study was modelled on Meltzoff's (1995) unfulfilled intentions paradigm. This paradigm is used to test typical

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children's understanding of intentions. For example, in one of the tasks, the model held a dumbbell shaped pull-apart toy. It appeared that the model was attempting to pull apart the toy; however, she did not succeed because her hand ''slipped'' off the object. Aldridge et al. (2000) claimed that the autistic children actually performed better than mental age-matched typically developing children (TD) in that the CWA produced more target acts (e.g. pulling-apart the toy) than the TD. Similar results were found by Carpenter, Pennington, and Rogers (2001) who showed that 2½–5 year-olds with autism produced as many target acts as children with developmental delays (DDs) after observing the model demonstrate the unfulfilled intentions.

While these studies seem to indicate intact understanding of intentions, closer inspection indicates this conclusion is premature. Russell and Hill's (2001) sample included only older children. More importantly, their sample was somewhat atypical in that the CWA failed to show autism-typical deficits in theory of mind (Russell & Hill, 2001). Deficits in intention reading could still be present in younger children. Both Aldridge et al. (2000) and Carpenter et al. (2001) tested younger children; however the comparison group used by Aldridge et al. (2000) was quite young with seven of the ten children falling below 11 months of age. It is possible that the object imitation tasks were beyond this group, rendering the comparison between the autism group and the typically developing group meaningless (Bellagamba & Tomasello, 1999). Finally, several issues with the unfulfilled intentions task cloud its interpretation.

The greatest difficulty with the unfulfilled intentions paradigm is that the child could succeed in carrying out the (unseen) intended actions without any understanding of the adult's intentions (Huang, Heyes, & Charman, 2002, 2006). For example, if one mimics the actions modelled on the pull-apart toy, it is conceivable that the pull-apart toy might come apart, without any reasoning as to what the model intended. Alternatively, the model's actions may have simply brought the child's attention to an aspect of the toy he or she would not have attended to otherwise (Huang et al., 2002). Aldridge et al. (2000) only presented children with the unfulfilled intentions. However, Carpenter et al. (2001) included several control conditions, allowing us to evaluate these alternatives. These included a baseline condition, where children simply played with the object, a target condition, where children saw the complete action and the outcome modelled, a manipulation condition where aspects of the object near but not integral to the target action were manipulated, and an end-state condition where the children were presented with the end state of the target action (e.g. the dumbbell already pulled apart with no demonstration of the action; Bellagamba & Tomasello, 1999; Meltzoff, 1995). For our purposes, the most interesting finding concerns the manipulation condition. CWA produced as many target acts in the manipulation condition as in the intended (but unfulfilled) condition. This effect was not found for children with DDs. These results indicate that the CWA may have benefited from a ''spotlighting effect'' where the adults' actions simply brought the child's attention to certain aspects of the toy, and the children were able to determine what actions could be produced on the toy.

Given the interpretation difficulties associated with the unfulfilled intentions tasks (Huang et al., 2002) it is important to document whether CWA would do as well on other tasks measuring children's understanding of intentions. Intentional actions often involve an observable outcome as well as an emotional reaction and other non-verbal behaviour from the person performing the action. Thus, the same action can be interpreted differently, depending on the accompanying emotional reaction and overall behaviour of the actor (Tomasello, Carpenter, Call, Behne, & Moll, 2005). Furthermore, Tomasello et al. (2005) suggest that understanding others' intentions involves both the cognitive understanding of goal-directed actions and the social motivation to identify with and share those emotional reactions with others. In TD, these two processes are intricately entwined (Tomasello et al., 2005). In contrast, the ability of CWA to understand goal-directed action may be relatively intact while the social-communicative functions associated with intention reading may be particularly affected (Rogers, Cook, Young, & Giolzetti, 2005; Rogers, Hepburn, Stackhouse, & Wehner, 2003; Tomasello et al., 2005).

In the straightforward case of a successful instrumental action (e.g. opening a container), little reliance is likely needed on social-communicative cues to infer the actor's intentions. However, distinguishing between accidents, failures and teasing often requires observing and interpreting the model's overall behaviour. TD demonstrates an understanding of intentions in these contexts during their second year of life (Behne, Carpenter, & Call, 2005; Carpenter, Akhtar, & Tomasello, 1998a). That is, not only do TD pay attention to the goal-directedness of the action, they also observe, and respond to, the overall behaviour of the actor. CWA have not been tested in these contexts, but we predict they would show impairments on tasks requiring reliance on the model's cues rather than using outcome of the action or the constraints of the objects to infer intentions.

To test the hypothesis that CWA would have more difficulty understanding intentions when required to rely on the model's behaviour, we used a procedure developed by Carpenter et al. (1998a) to test TD's understanding of intentional versus accidental actions. In this procedure, a model demonstrated both an ''intentional'' and an ''accidental'' action on the same toy. In another condition, the model demonstrated two ''intentional'' actions on the same toy. Intentional actions were marked by the experimenter saying ''There'' while accidental actions were marked by the experimenter saying ''Whoops''. After completing both actions, an outcome (such as lights flashing) was activated. This paradigm eliminates the possibility that children can succeed due to the constraints of the toys or because the experimenter's actions highlight the functions of the toys: each toy affords two actions and the experimenter models two actions. Typically developing 14–18 months old generally produce more intentional than accidental actions using this paradigm and this is thought to demonstrate an understanding of others as intentional beings (Carpenter et al., 1998a; Olineck & Poulin-Dubois, 2005). To ensure that the intentional and accidental actions were equally salient, we minimized the non-verbal cues. However, as in Carpenter et al. (1998a), some non-verbal cues remained (accidental actions were slightly quicker and jerkier and some facial expressions remained). Since we were concerned with whether CWA would respond differentially to the overall behavioural cues of the model (i.e. not just whether they discriminated the words ''whoops'' or ''there'') we were not concerned if some non-verbal cues remained.

To compare our work with Aldridge et al. (2000) and Carpenter et al. (2001) we tested preschoolers with autism. Children with global DD and TD, both matched for verbal ability to the CWA served as comparison groups. We chose to match on verbal ability because language and imitation skills are correlated in both TD and CWA and because autism always involves deficits in communication (Carpenter et al., 1998b; Carpenter et al., 2001; Smith & Bryson, 1994). To compare our work with previous research using this paradigm (Carpenter et al., 1998a; Olineck & Poulin-Dubois, 2005), we included a group of younger TD. We expected CWA to produce target acts without reference to intentions. Specifically, we expected them to imitate both intentional and accidental actions and to imitate as many two-action sequences when both intentional and accidental actions were modelled as when two intentional actions were modelled.

Methods

Participants

Children with Autism

Children with autism were recruited by asking local autism support groups and health care specialists to circulate information to families with CWA. Advertisements were also placed in newspapers. Seventeen children were recruited (M = 53 months; SD = 7 months; range = 42–67 months). All children received a diagnosis of autistic disorder from a qualified paediatrician or paediatric neurologist.

Children with Global Developmental Delay

Children with global DD were recruited similarly to the CWA except that recruitment materials specified that we were seeking children with a global DD, not including autism. This resulted in a sample of six children, four with Down Syndrome and two with DDs of unknown origin (mean age = 61 months; SD = 18 months; range = 41–87 months). Because of the small sample size, results from this group must necessarily be viewed with caution.

Typically Developing Children

The TD were recruited by searching newspaper birth announcement archives and by posting advertisements in local newspapers, daycares and on bulletin boards. Two samples were recruited, an older TD sample of 14 children (M = 40 months; SD = 11 months; range = 18–57 months) and a younger TD sample of 21 children. One younger TD child had to be excluded because the mother provided help to the child. The remaining 20 children had a mean age of 16 months, 13 days (SD = 3 months, 11 days; range = 14 months, 19 days–18 months, 18 days).

Unfortunately, an error in recording procedures meant we were unable to determine demographics separately for the CWA, DD and older TD group. For the three groups combined, the majority of the parents of the children sampled had either a university degree (57%) or some college education (32%). Most were White (4% reported being Native, no other racial groups were represented). Most had a family income of $40,000 or higher (74%) with the modal income reported as 80,000 or higher.[1] In the younger TD sample, most parents held a university degree (75%) while the remainder reported some college education (25%). The modal family income was reported at $80,000 or higher with 76% of the sample reporting a family income of $40,000 or greater. The majority (90%) were White. The remainder were either Hispanic (5%) or Asian/Pacific Islander (5%).

Materials

Eight objects were made from either wooden or metal boxes using the same principles of design as described Carpenter et al. (1998a). That is, each object had two moveable attachments (e.g. a hinge, a door lever) and an outcome (e.g. party favour unrolling, lights flashing, a spinning top). Toys with lights and spinning tops were controlled via a corded remote. Toys with party favours were controlled via a piece of plastic tubing with a turkey baster, which allowed a puff of air to unroll the party favour. The outcomes were activated secretly by the tester to allow for experimental control over which action sequences produced the outcome. Two toys served as practice toys, while the remaining six toys were used in the testing procedure. The toys are pictured in Fig. 1 and described in Table 1.

Fig. 1 Photograph of toys used in study

Autism and Language Measures

The Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1988) was administered to all children. The CARS is an examiner-administered rating scale. Children are rated on a 7 point-likert scale along 15 behavioural and symptom dimensions. Scores are totalled to yield an overall score. Children who score above 30 are classified as having autism. The CARS shows high agreement with clinical diagnosis and scores have been shown to vary meaningfully with diagnostic category (Perry, Condillac, Freeman, Dunn-Geier, & Belair, 2005). Children in the current study were rated on a post hoc basis using the videotape of their session.

The Preschool Language Scale-3 (PLS-3; Zimmerman, Steiner, & Pond, 1992) was administered to the CWA, DD and older TD children to yield two language age equivalent scores: the Auditory Comprehension Score and the Expressive Communication Score. The Auditory Comprehension Score measures precursors to language comprehension (such as attending to speaker), understanding of vocabulary and relational concepts, understanding of syntactic structure, and the ability to use language to categorize and understand conceptual relationships. The Expressive Communication Score measures vocal development (production of sounds), social communication (use of non-verbal communication and social games, vocalization in response to others' communications, etc.), expressive vocabulary, use of grammatical markers (pronouns, plurals, etc) and ability to express oneself in a logical way (tell how objects are used, tell about remote events, name categories, define words, etc.; Zimmerman et al., 1992). The test takes ~20–30 min to administer. The DD and older TD children were matched to the CWA on the basis of auditory comprehension.

Design

Children completed the imitation task before the PLS-3. The reasoning for this was to obtain optimal

[1] In response to reviews of an earlier version of this manuscript, we mailed follow-up questionnaires to obtain further descriptions of our sample. In addition to demographics, we also asked parents to complete the Social Communication Questionnaire—Lifetime Version (SCQ; Berument, Rutter, Lord, Pickles, & Bailey, 1999). This questionnaire contains 40 yes–no questions about the child's lifetime presence of social-communication skills and autism symptoms. It shows high agreement with the Autism Diagnostic Observation Schedule and the Autism Diagnostic Inventory (Berument et al., 1999). Our response rates were 41, 67, 30 and 86% for the CWA, DD, Older TD and Younger TD groups, respectively. The demographics within the groups for those who replied mirrored the demographics of the overall sample. The SCQ data indicated that the autism sample scored within the autism cut-off, while the other three samples did not (*M*s = 18, 9, 4, 5 for the CWA, DD, Older TD and Younger TD groups, respectively, $F(3, 25) = 16.34$, $P < 0.001$, $\eta^2 = 0.66$).

Table 1 Description of toys used, actions performed and outcomes

Name	Base unit	Actions	Outcome
Practice toys			
Light switch toy	Metal box	Depress hand switch	Lights come on
Small bunny toy	Metal box	Spin dial press button	Small plastic bunny face spins
Test toys			
Hinge toy	Wood box	Lift screen door handle/hinge pull loop	Party favour unravelling
Bird house toy	Wood bird house	Lift hinge spin wheel	Party favour unravelling
Apple toy	Wood box	Press button lift swinging door stop	Translucent centre lights up in apple pattern
Propellor toy	Wood box	Lift hinge press light switch	Plastic propellor spins
Light house toy	Wood crate	Press button slide knob	Light in light house comes on
Bunny toy	Metal box	Spin dial flip switch	Plastic bunny Play Doh cutter spins

performance on the imitation task. For the imitation task, either an accidental action and an intentional action or two intentional actions were modelled on each toy in a two-action sequence similar to that used by Carpenter et al. (1998a) with typically developing children. The accidental actions were marked by the word ''Whoops!'' and intentional actions were marked by the word ''There!''. All attempts were made to ensure that the two types of actions (accidental and intentional) were equated as much as possible and that all other verbal and non-verbal cues were kept to a minimum. Thus, the same actions were modelled whether they were meant to be intentional or accidental. The actions were scripted and rehearsed so that they looked plausible as either intentional or accidental actions (see Table 1 for a description of the actions). In the case of a button press, it looked as if the tester accidentally put her hand down on the button, realized her mistake, lifted her hand, and then said ''Whoops''. Typically developing children reportedly have no difficulty determining which is the intentional action under these circumstances, and will imitate more intentional than accidental actions (Carpenter et al., 1998a; Olineck & Poulin-Dubois, 2005). Three conditions for the two-action sequences were used. Following Carpenter et al. (1998a) the conditions were Accidental–Intentional (A–I), Intentional–Accidental (I–A) and Intentional–Intentional (I–I). As in Carpenter et al. (1998a), the I–I condition was used to avoid demonstrating too many accidental actions and to provide a stronger test of children's ability to distinguish between intentional versus accidental actions. Each condition had two toys associated with it and each toy was presented in two successive trials. Each child received each condition (thus, each child saw actions modelled on six toys across a total of 12 trials—four trials per three conditions). The toys and actions assigned to each condition were randomized by the throw of a die. No set order was used for toy administration. Essentially, the experimenter reached for whichever toy was handy with the constraint that no two consecutive sessions began or ended with the same toy. The imitation task took ~20–30 min.

Procedure

The CWA were tested in settings that were familiar to them (e.g. school, home). Children with global DDs were tested either in familiar settings or in the laboratory. The typically developing samples were tested in the laboratory. Our reasoning for testing CWA and some children DD in familiar settings was partly because we were concerned about the ability of the CWA to perform in unfamiliar settings and partly because we had to travel to various regions of the province to collect our clinical samples and did not have access to laboratory settings in remote locations.

Testing was conducted either on the floor or at a table by two experimenters. E1 sat facing the child and E2 sat behind and to the side of E1. E2 readied the toys and passed them to E1. E1 interacted with the children and demonstrated the toys. The same person modelled the actions for the CWA, DD and older TD groups. Another E1 (who was trained by one of the original experimenters) modelled the actions for all the younger TD children. The original E1 and E2 both had experience working with CWA. In all trials, children were prevented from touching the toys until the model completed the demonstration. Toys were stored and transported using an opaque, rectangular, plastic storage bin. When testing was done on the floor, the storage bin was positioned strategically so the toys could be placed in front of the container by E1 while E2 surreptitiously activated the outcome by positioning herself behind the container. When testing was done at a table, toys were brought from under the table and E2 activated them surreptitiously under the table. Sessions were videotaped for later analyses.

The imitation task began with a training phase where E1 modelled both one- and two-action sequences. The purpose of this phase was threefold: (a) to train the children to imitate E1; (b) to screen out children who could not imitate; and (c) to avoid creating either a one- or two-action response bias. E2 began by passing the light switch toy to E1 who said ''Watch. I'm going to show you how this works''. E1 then depressed a hand switch on the toy and E2 secretly activated the lights atop of the toy. No accidental actions were modelled during the training phase and no further comments were made by E1. After the lights went out, E1 pushed the toy closer to the child and said, ''Now you try. Can you make it work?'' If the child did not reproduce the action, E1 provided another trial including a model (as before) and another opportunity to reproduce the action. If necessary, E1 used verbal instructions and manual prompting to teach the child to perform the action. E1 continued in this manner until the child had performed the action independently several times. After training with the first toy, E2 brought out the small bunny toy and E1 repeated the training procedure with two actions. E1 turned a dial and pressed a button and then a small plastic knob with a raised bunny pattern began to spin. Children were required to imitate both actions, in correct sequence. If children did not perform both actions in sequence, E1 provided instruction as before. Based on previous research we anticipated that CWA would be able to imitate both single and two-action sequences (Aldridge et al., 2000; Carpenter et al., 2001; Smith & Bryson, 1998).

Testing began immediately after training. E1 modelled the two-action sequence depending on order (A–I; I–A; or I–I) and then said to the child ''Now you make it work'' or ''Your turn''. E2 activated the outcome within one second of E1's completion of the second action. This was to reduce the possibility that the child was simply learning an action-end result, S–R sequence. Rather, the child would have to reason, based on the model's cues, which was the relevant, intentional action and which action was irrelevant to the model's intended goal. For the A–I and I–A orders, only one action (the intentional action) appeared relevant to the outcome, while the accidental action appeared irrelevant. For the I–I order, both actions appeared relevant.

Children were permitted to respond immediately after the demonstration. The outcome activation after the children's responses depended on the order demonstrated. For I–I demonstrations, the outcome was activated after the child's second action, provided the child imitated the actions in the correct order. For both the A–I and I–A demonstrations, the outcome was activated after the children reproduced the intentional action, regardless of whether they reproduced the accidental action. However, as in Carpenter et al. (1998a), 2 s were allowed to elapse after the child produced the intentional action in the I–A condition so that children had time to reproduce the accidental action. Since CWA and other related developmental disabilities are typically given 2–3 s to formulate a response to instructions during behaviour treatments (Lovaas, 2003), this delay seemed adequate for the children in this study. Children's intentional actions were rewarded with the outcome if it looked like they were attempting to reproduce the action (i.e. they were not ''penalized'' if they were unable to perform the action due to motor or strength difficulties).

Data Reduction

Responses were scored from the videotape by a coder who was naive to the hypotheses.[2] The coder was aware of the condition but was not told to what group a child belonged; however, it is likely that the coder was able to determine group membership when watching the video. For each trial, the coder determined what actions the child imitated and in what order the actions were performed. Based on this determination, responses were then designated as falling into one of four categories. For the A–I and I–A trials these categories were Intentional-Only, Accidental-Only, Intentional–Accidental and Accidental–Intentional. For the I–I trials these categories were First Intentional Action Only, Second Intentional Action Only, Intentional Action One followed by Intentional Action Two and Intentional Action Two followed by Intentional Action One. Trials where a child failed to respond were omitted since we were concerned with what children would do *when they imitated*. This mean that: 15% (SE = 8.3), 16% (SE = 8.0) and 19% (SE = 8.4) of A–I, I–A and I–I trials, respectively, were omitted for CWA; 4% (SE = 4.2), 8% (SE = 8.3) and 8% (SE = 8.3) of A–I, I–A and I–I trials, respectively, were omitted for children with DD; 2% (SE = 2) of A–I trials were omitted for older TD children; and 6% (SE = 3.1), 11% (SE = 4.6) and 9% (SE = 3.8) of A–I, I–A and I–I trials, respectively, were omitted for younger TD children. Scores were converted to percentages within each condition (i.e. A–I, I–A, I–I) since not all children received four trials in each condition. A second coder scored 25% of each sample for inter-rater reliability. This observer was blind to

[2] Technical problems interfered with the recording of one child with autism and one child with developmental delay. In these cases, E2 recorded the child's response live.

condition, group and the hypotheses. Interobserver agreement was 92% (Cohen's kappa = 0.89).

Results

All children passed the one-action practice. Three CWA one DD child and one older TD child failed to imitate during the two-action practice trials. The younger TD children had considerably more difficulty with the two-action practice than the older children. Only five of the younger children passed the two-action sequence. Analyses conducted with and without the children who failed the two-action practice did not differ from each other; therefore, the data for the entire sample of children was included. Not all of the children completed the PLS. In particular, children tended to have more difficulty completing the expressive communication scale, most likely because it was the last item administered and children may have become restless by this time. Thus, expressive communication language scores should be viewed with caution.[3] Age, CARS and language scores along with Ns for the groups can be found in Table 2. The four groups differed significantly in age ($F(3,53) = 73.74$, $P < 0.001$ $\eta^2 = 0.81$). Significant group effects were followed up with Tukey's LSD comparisons using $P = 0.05$ as the cut-off for significance. All groups were significantly different from each other (i.e. all $ps < 0.05$). The groups also differed in their CARS scores ($F(3,44) = 23.76$, $P < 0.001$, $\eta^2 = 0.62$). Though the mean CARS score for the CWA did not reach clinical cut-off, scores are likely attenuated due to the fact that this was a research protocol and we did not attempt to elicit certain behaviours (such as responses to taste, smell and touch) that did not occur during testing. CWA did have significantly higher CARS scores than the other three groups (all $ps < 0.01$) and our general impression was that these children had autism. Children with DD had significantly higher scores than both TD groups (both $ps < 0.05$). The TD groups did not differ significantly from each other. The three groups which were administered the PLS-III differed in expressive communication ($F(2,22) = 4.52$, $P < 0.05$ $\eta^2 = 0.29$). The older TD children had significantly greater expressive communication than the other two groups children (both $ps < 0.05$). The differences between the two clinical groups did not reach significance. The three groups did not differ from each other on auditory comprehension.

Our analyses parallel those done by Carpenter et al. (1998a). To determine if children imitated more intentional than accidental actions a 2 (type: intentional versus accidental) × 2 (condition: A-I versus I-A) × 4 (group: autistic, DD, older typical, younger typical) mixed ANOVA was conducted. The I–I trials were omitted from this analysis, since there were no accidental trials for comparison in this condition. For this analysis, responses were scored as intentional or accidental regardless of whether the child's order of response matched E1's order of response or whether the child produced one or both actions. This analysis yielded a main effect of type ($F(1,53) = 34.41$, $P < 0.001$, $\eta^2 = 0.39$). Children imitated intentional actions on 84% of trials (SE = 3.6) whereas they imitated accidental actions on 53% of trials (SE = 5.1). This main effect is qualified by a type by group interaction ($F(3,53) = 3.77$, $P < 0.05$). Only children with DD (intentional: $M = 79$, SE = 10; accidental: $M = 50$, SE = 14, $P = 0.05$) and the TD groups (older TD intentional: $M = 97$, SE = 6; accidental: $M = 52$, SE = 9; younger TD intentional; $M = 86$, SE = 5 accidental: $M = 43$, SE = 8 both $ps < 0.001$) showed this pattern. The CWA did not show a significant difference between the amount of intentional ($M = 75$, SE = 6) versus accidental ($M = 67$, SE = 5) actions imitated ($P > 0.05$).

The next set of analyses examined the different response types according to condition. Children who were responding based on the model's intentions were expected to produce more Intentional-Only (I-Only) actions in the A–I and I–A conditions and more Intentional-One followed by Intentional-Two (I1–I2) actions in the I–I condition. A 4 (response type) × 3 (condition A-I, I-A, I-I) × 4 (group) mixed ANOVA was conducted first. The results are found in Table 3. As can be seen, a number of main effects and interactions reached significance. In light of the three-way interaction between condition, response type and group ($F(18, 318) = 3.92$, $P < 0.01$, $\eta^2 = 0.18$), only this effect will be interpreted. The three-way interaction was followed up with Tukey's LSD post hoc comparisons using $P = 0.05$ as the cut-off for significance. The four different response types for each condition are plotted by group in Fig. 2. Within each group and condition, bars with asterisks above them are significantly greater than the others. The presence of two asterisks indicates that both bars are significantly greater than the others but not significantly different from each other. The results of the CWA suggest they were copying the model's actions

[3] To ensure that there were no differences between those who completed the PLS and those who did not, all analyses were run with completion status as a factor. Interpretation of results did not change.

Table 2 Mean chronological age, CARS and PLS-3 language age scores for participants by group

Group	Chronological age	CARS Score	PLS-3	
			Auditory comprehension*	Expressive communication*
Autism (N = 17)				
M	53[a]	29[a]	33	29[a]
(SE)	(2.1)	(1.7)	(4.3)	(4.1)
Range	42–67	19–38	6–56	7–50
Delay (N = 6)				
M	61[b]	22[b]	32	26[a]
(SE)	(3.5)	(2.8)	(9.4)	(11.7)
Range	41–87	17.5–33	8–59	12–49
Older typical (N = 14)				
M	40[c]	16[c]	44	48[b]
(SE)	(2.3)	(0.4)	(3.3)	(5.2)
Range	18–57	15–19.5	24–64	20–77
Younger typical (N = 20)				
M	16[d]	17[c]	–	–
(SE)	(1.9)	(0.64)	–	–
Range	15–19	15–24	–	–

* Age in months. Means within columns with same letter superscript not significantly different

without reference to her intentions. In all three conditions, the most frequent response was to copy exactly what the experimenter modelled. In the A–I condition, the A–I response was produced on 60% of trials. In the I–A condition, the I–A response was produced on 53% of trials. In the I–I condition, the I1–I2 response was produced on 62% of trials. In all three conditions, these responses were produced significantly more often than any other response. Children with DD and TD children showed a different pattern. The DD and older TD children produced equal I-only and exact copies in the A–I and I–A conditions and significantly more I1–I2 responses in the I–I condition. Younger TD children showed significantly more I-Only responses than any other response in the A–I and I–A conditions. In the I–I condition, they showed no difference between I1–I2 responses and the other response types.

Next, a 3 (condition: A–I, I–A, I–I) × 4 (group) ANOVA was done on the number of two-action responses. If children were paying attention to the model's intentions, we would predict more two-action sequences in the I–I condition than the A–I or I–A conditions. As expected, this analysis yielded a main effect of condition ($F(2,106) = 19.53$, $P < 0.001$, $\eta^2 = 0.27$). Children produced significantly more two-action sequences in the I–I condition (M = 44%, SE = 3.10) than either the A–I (M = 27%, SE = 3.79, $P < 0.001$) or I–A conditions (M = 28%, SE = 4.11, $P < 0.001$). The group main effect was non-significant. The interaction between group and condition reached marginal significance ($F(6,106) = 2.01$, $P = 0.07$, $\eta^2 = 0.10$). Since we had specific hypotheses regarding this interaction, we chose to examine the differences among the mean scores. Tukey's LSD analyses revealed that the children with DD and the TD children produced significantly more two-action sequences in the I–I condition than the other two conditions (DD and younger TD groups: I–I versus A–I and I–I versus I–A both $ps < 0.01$; younger TD group I–I versus A–I $P = 0.06$; I–I versus I–A $P < 0.01$). In contrast, the CWA produced as many two-action sequences in the A–I and I–A conditions as they did in the I–I condition (I–I versus A–I and I–I versus I–A both $ps > 0.05$; see Fig. 2).

Since imitation has been linked with language (Carpenter et al., 1998b, 2001) it is important to rule

Table 3 Group by condition by response type effects

Effect	Degrees of freedom	F	Sig. F	η^2
Group	3,53	2.86	0.05	0.14
Condition	2,106	0.74	0.48	0.01
Cond × group	6,106	0.53	0.78	0.03
Response type	3,159	10.9	0	0.17
Resp × group	9,159	3.71	0	0.17
Cond × resp	6,318	22.75	0	0.3
Cond × resp × group	18,318	3.92	0	0.18

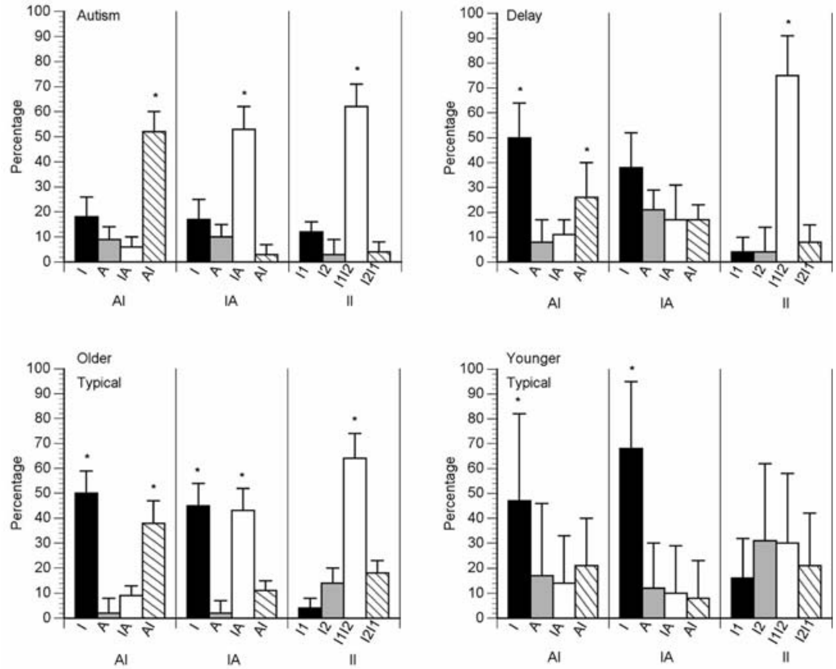

Fig. 2 Response types by condition and group. Lines represent standard error

out the possibility that our results are due to differences in language ability and not due to group differences in diagnostic category. Since the older comparison groups were matched for auditory comprehension, it seemed unlikely that verbal comprehension skills were responsible for the group differences. Nonetheless, we calculated an Intentionality Difference Score by subtracting the amount of accidental actions produced from the amount of intentional actions produced and then correlated this difference score with the child's language scores. Younger TD children were left out of this analysis because they were not administered the PLS-III. Pearson Product Moment correlations were essentially zero (r = –0.05; $P > 0.05$ and $r = 0.05$, $P > 0.05$ between the Intentionality Difference Score and PLS-III Auditory Comprehension Age and PLS-III Expressive Communication Age, respectively).

We next looked at individual responding to determine to what extent the results of the ANOVAs reflected the performance of individuals (see Table 4). The numbers of children in both TD groups who produced more intentional than accidental actions reached significance (86% of older TD and 85% of younger TD children; both ps < 0.05, sign test). This difference did not reach significance for the DD group [67% (ns) or the CWA group 41% (ns), though fewer CWA showed this pattern]. Looking at the numbers of children whose most frequent response was the intentional-only response in the A–I and I–A conditions, the number of CWA who produced the intentional-only response as their most frequent response was significantly *less* than expected by chance (11% in the A–I and 18% in the I–A conditions, respectively, both $P < 0.05$, sign test). The results from the DD and older TD groups failed to reach significance. The number of younger TD children who produced the intentional-only response as their most frequent response was signficantly *more* than expected by chance in the I–A condition (75%, $P < 0.05$). The number of younger TD children producing the intentional-only response as the

Table 4 Examination of individual responses across groups

	Group			
	Autism $n = 17$	Delay $n = 6$	Older typical $n = 14$	Younger typical $n = 20$
A < I	41% (7)	67% (4)	86% (12)**	85% (17)*
A–I–I greatest	11% (2)*	50% (3)	43% (6)	35% (7)
I–A–I greatest	18% (3)*	50% (3)	43% (6)	75% (15)*
I–I–I1I2 greatest	71% (12)*	67% (4)	64% (9)	15% (3)*
A–I–mimic greatest	59% (10)	33% (2)	43% (6)	10% (2)*
I–A–mimic greatest	59% (10)	17% (1)	36% (5)	10% (2)*

Number of children exhibiting response is in brackets

* Sign test $P \leq 0.05$

** Sign test $P < 0.01$

most frequent response in the A–I condition failed to reach significance. The majority of children in the CWA, DD and older TD groups produced the I1–I2 response as their most frequent response in the I–I condition, though this only reached significance for the autism group (79%, $P < 0.05$, sign test for autism group). The number of younger TD children who produced the I1–I2 response most frequently was significantly less than expected by chance (15%, $P < 0.05$, sign test). Finally, looking at the numbers of children whose most frequent response was to copy the experimenter's actions exactly in the A–I and I–A conditions indicates that the CWA produced this response more frequently than the other groups. However, the only effect to reach significance was that the number of younger TD children who produced an exact copy was significantly less than expected by chance (10%, $P < 0.05$, sign test for both conditions).

In their paper, Carpenter et al. (1998a) noted that children were being rewarded for producing intentional actions (i.e. the outcome was activated after the child produced an intentional action). Thus, they argued that it was important to rule out practice or conditioning effects. To do this, they examined children's responses on the first trial versus the second trial averaged across all six toys as well as their performance on the first versus the last toy. We performed similar analyses. The children's responses on each trial were categorized as either correct or incorrect. For these purposes, a correct response would be to produce the I-only response in the A–I or I–A conditions or the I1–I2 response in the I–I condition. Any other response is considered incorrect. For the first analysis, children's responses were collapsed across toys. A 4 (group) × 2 (responses 1 and 2) mixed ANOVA on the correct responses revealed only a significant effect of group ($F(3,53) = 3.30$, $P < 0.05$, $\eta^2 = 0.16$). Tukey's LSD post hoc comparisons revealed that the CWA produced significantly less correct responses than either the DD ($P < 0.05$) or older TD children ($P < 0.01$) but not the younger TD children (see Table 5).

Next we examined the children's best responses on the first toy versus the last toy and whether they produced accidents on the first toy where accidents were modelled versus the last toy where accidents were modelled.[4] A 4 (group) × 2 (first toy, last toy) mixed ANOVA on the best response on the first toy versus the best response on the last toy revealed no effects. A 4 (group) × 2 (first toy, last toy) mixed ANOVA on the number of children who produced accidents on the first toy where accidents were modelled versus the last toy where accidents were modelled revealed a group by response interaction ($F(3,51) = 2.71$, $P = 0.05$, $\eta^2 = 0.14$). Tukey's LSD post hoc comparisons revealed that the DD children produced marginally less accidents on the last toy where accidents were modelled than on the first toy where accidents were modelled ($P = 0.07$) whereas the older TD children produced significantly more accidents on the last toy where accidents were modelled ($P < 0.05$). The other two groups showed no differences.

[4] Technical difficulties resulted in one DD and older TD child missing data for analyses comparing percentage correct on first toy versus last toy and the same DD and one younger TD child missing data for percentage of accidents performed on the first toy verus last toy where accidents were modelled. Details are available from the authors.

Discussion

In this study, we were interested in whether CWA would selectively imitate intentional actions after observing an actor demonstrate both intentional and accidental actions on the same object. Previous research where actors demonstrated unfulfilled intentions indicated that CWA were able to produce an intended action, even when they had not observed the actual action take place (Aldridge et al., 2000; Carpenter et al., 2001). However, we argued that the children could have succeeded on this task without attending to the actor's intention (Huang et al., 2002, 2006). We argued that attending to the overall behaviour of the actor would be a better test of whether CWA attend to the actor's intentions, since these are the cues that allow one to distinguish between things such as intentional actions, accidents and teasing (Behne et al., 2005; Carpenter et al., 1998a; Tomasello et al., 2005). Since CWA may have relatively intact ability to understand simple goal-directed actions but be specifically impaired in their ability to attend to the social-communicative cues signifying intentions (Rogers et al., 2003, 2005; Tomasello et al., 2005), we expected this to be a difficult task for these children. Specifically, we expected the CWA to produce as many intentional as accidental actions and to produce two-action sequences as often when two intentional actions were modelled as when only one intentional action was modelled.

Our results were consistent with predictions. The CWA did not produce more intentional than accidental actions. Instead, they were more likely to reproduce the same actions in the same order as the experimenter, in all three conditions. Nor did they produce more two-action sequences when the experimenter

Table 5 Means from analyses examining learning effects

	Group			
	Autism	Delay	Older typical	Younger typical
Response 1—% correct*	31 (5.8)	53 (9.8)	54 (6.4)	44 (5.4)
Response 2—% correct*	32 (6.3)	56 (10.5)	57 (6.9)	41 (5.8)
First toy—% correct*	59 (11.7)	40 (21.5)	77 (13.4)	70 (10.8)
Last toy— % correct*	24 (11.7)	80 (21.6)	39 (13.4)	50 (10.8)
First toy—% accidents*	65 (12.1)	80 (22.4)	43 (13.4)	58 (11.5)
Last toy—% accidents*	77 (11.6)	40 (21.5)	71 (12.8)	58 (11.0)

Standard error in brackets

*Refers to percentage of infants obtaining the indicated response

modelled two intentional actions compared to when the experimenter modelled one intentional and one accidental sequence. In contrast, the results of the other groups demonstrate an appreciation of intentionality. The results of the younger TD children were most consistent with previous research (Carpenter et al., 1998a; Olineck & Poulin-Dubois, 2005). This group produced more intentional actions than accidental actions, more Intentional-only responses than any other response type in the A–I and I–A conditions, and more two-action sequences in the I–I condition than the other two conditions. Finally, the results of the older TD children and the children with DD differed somewhat from the younger TD children but were still consistent with an understanding of the adult's intentions. Although they produced the I-only response as often as an exact copy in the A–I and I–A conditions, they produced more two-action sequences in the I–I condition than the A–I or I–A conditions and imitated more intentional than accidental actions. Furthermore, when they imitated only one action, that action tended to be the intentional action. They rarely imitated only the accidental action.

It is unlikely that the group differences were due to difference in verbal ability: the three older groups did not differ significantly in language comprehension; there were no differences when we compared those who had complete language data versus those who failed to complete the language measure; and there was no significant correlation between language comprehension and their intentionality score. It is also unlikely that our effect is an artifact of "over-learning" to imitate adults exactly as might be (inadvertently) taught in imitation-based intervention programs. We have no data to speak to this possibility; however, at the time of data collection, treatment programs for CWA were not readily available in our province.

To understand the children's responses, it is helpful to situate our results within a social learning context. Tomasello, Kruger, and Ratner (1993) proposed several types of social learning. Stimulus enhancement is said to occur when an individual's attention is drawn to aspects of an object to which that individual would not otherwise have attended. Emulation occurs when an individual pays attention to the goal or end state but not the means used to achieve the goal. Mimicking involves copying the exact actions of another without attention to the goal. None of these, according to Tomasello et al. (1993) involve understanding the actor's intentions. To qualify as understanding intentions, the learner must attend to both means and goal (imitative learning). Thus, imitative learning is "learning in which the learner is attempting to learn not *from* another, but *through* another" (Tomasello et al., 1993, p. 496, emphasis in original).

To help evaluate whether our results could be explained by Tomasello et al.'s (1993) social learning processes, we supplemented our main analyses by reviewing our videotapes for other social-communicative behaviours. Specifically, we noted the amount of looking and smiling directed towards the adult's face while the adult was demonstrating the actions, during the period of time when the child was given to imitate the actions and within 2 s of the outcome. We reasoned that if the typical and DD children were producing exact matches in the A–I or I–A conditions because they believed that we intended them to "pretend" to have accidents, they may show more smiling or looking towards the model when imitating accidents.[5] We also noted the frequency with which the children looked in anticipation of the outcome. Such looking could be taken as evidence that the child was interested in the goal of the action (i.e. to produce the outcome; Carpenter et al., 1998a). Because our original, main emphasis was on recording the child's hands and object, we were only able to observe the child's face and eyes in about two-thirds of the sessions. Our observations indicated that CWA gazed and smiled less at the experimenter than the typically developing or DD children. All children, in all four groups, gazed at the outcome in excess of 80% of the trials.

[5] Thanks to an anonymous reviewer for pointing this out to us.

Following the definitions above, and taking into account the children's looking in anticipation of the outcome, we argue that the behaviour of the CWA most closely resembles stimulus enhancement. While the predominant response for these children was to reproduce the same actions in the same order as the experimenter, the fact that they looked in anticipation of the outcome appears to rule out a mimicking response. This is consistent with our argument that a spotlighting effect was responsible for their success in the unfulfilled intentions studies (Aldridge et al., 2000; Carpenter et al., 2001); however, unlike in the unfulfilled intentions task, where stimulus enhancement helped the child succeed, stimulus enhancement hindered performance in the current task. In the current study, the objects afforded two actions and the experimenter modelled both actions. Thus, a spotlighting effect of the experimenter's actions would not have benefited the child. The child had to rely on the model's overall cues (verbal and non-verbal) to determine which action was intentional and which was accidental.

The results of the three remaining groups are most consistent with imitative learning. While the older TD and DD groups produced an elevated number of exact copies this is consistent with recent findings that 3 and 4 year-olds (but not younger) imitate the failed attempts in the unfulfilled intentions task (Huang et al., 2006). The production of mostly intentional actions, combined with their looking towards the outcome and social-communicative behaviours directed towards the model, suggest that the three remaining groups were not simply focussed on means or ends. The increased number of accidents produced by the older children may be an artifact of the number of accidents modelled (Carpenter et al., 1998a). Carpenter et al. (1998a) made this argument for the younger infants in their study. Perhaps this effect is more pronounced with older samples: the older TD children showed a significant increase in the number of accidents performed from the beginning of the experiment to the end of the experiment. They also performed more accidents than the younger infants tested by Carpenter et al. (1998a).

It has been suggested by Tomasello (1995, 1999) that the understanding of others as intentional is the foundation upon which joint attention and the more complex theory of mind abilities are built. CWA have well-documented difficulties with joint attention and theory of mind and therefore, one might reasonably expect them to also have difficulty understanding others' intentions. Our results are consonant with this expectation. These findings are also consistent with a number of researchers who have suggested that social-motivational processes play a role in the understanding of intentions and joint attention. For example, it may be that an understanding of intentions is necessary to engage in joint attention but one must also have the social-affective motivation to actively share the experience with others (Carpenter et al., 2001; D'Entremont, Yazbek, Morgan, & MacAulay, 2006, submitted data; Mundy, Sigman, & Kasari, 1992; Mundy & Willoughby, 1996; Tomasello et al., 2005).

A recent proposal by Rogers and colleagues illustrates how this applies to imitative learning (Rogers et al., 2003). These authors suggested that imitative behaviour could be broken into two functions, a social-communicative function and an apprenticeship function. The social-communicative function essentially serves to connect one individual to another through imitation of facial expressions and body movements while the apprenticeship function serves to allow one to learn to perform instrumental actions on objects. They suggest that CWA are impaired only in the social-communicative function and not the apprenticeship function. This would explain why CWA have more difficulty imitating manual actions than actions on objects. It would also explain why non-responsiveness has not been a problem on either the unfulfilled intentions tasks or on our task, in spite of well documented difficulties with imitation in CWA (Rogers & Pennington, 1991; Smith & Bryson, 1994; Williams, Whiten, & Singh, 2004). Intact perception of goal-directed actions and apprenticeship functions of imitation would allow CWA to attend to others' actions to determine how objects work. The fact that the CWA produced both actions in order (not randomly) and looked at the outcome suggests that they are oriented towards goals. This attention to goal-directed action would lead to success on the unfulfilled intentions task but failure on our task. Even though both tasks required the children to perform instrumental actions, our task tapped into the social-communicative function of imitation by requiring children to attend to the model's overall verbal and non-verbal behaviour. In contrast, the unfulfilled intentions task tapped into the apprenticeship function since success on this task could be achieved by attending only to the instrumental actions.

One caveat needs mention. The sample size for the group with DD was small; thus the results for this group should be viewed with caution. Clearly, replication with more children should be a priority. In addition, we would have liked the resources to include a confirmatory diagnostic work-up. However, we are confident in our group designations. The

CARS scores (and SCQ where available) differentiated between the two clinical groups. In addition, the CWA directed fewer social-communicative behaviours towards the experimenter than the other groups. Finally, 4/6 of the DD sample had Down Syndrome. While mental retardation is known to accompany autism, there is no reason to believe the incidence of autism is increased in children with Down Syndrome (Fombonne, 2003). Therefore, despite the small sample sizes, we believe that the current study provides important information about the ability of CWA to attend and respond to the intentions of others in a task where they are not able to rely on the objects themselves to determine what actions are required.

In summary, we have argued that CWA did not respond on the basis of the experimenter's intentions. Rather, we argued that their responses were due to stimulus enhancement, that is, the model's actions drew attention to the affordances of the objects and the children then performed the actions that the objects afforded. Future research would benefit from carefully teasing apart the ability of CWA to perceive goal-directed action versus their social motivation to share those goals with others. The children did give some indication that they attended to the goal, even though they failed to use the overall behaviour of the model to determine her intentions. Along this line, it will be important to find a paradigm for testing low functioning, non-verbal children and for procedures which do not rely on imitation. Highly verbal children, who are able to report on their own or others' intentions (such as the procedure by Russell & Hill, 2001) may have a different level of social understanding than non-verbal children while motor planning aspects of imitation tasks could cloud the children's performances for reasons other than their perception of intentions (Hill, 2004; Hughes, Russell, & Robbins, 1994; Lopez, Lincoln, Ozonoff, & Lai, 2005). Such research will be fruitful not only for understanding autism but also for a broader understanding of the development of social cognition.

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References

Aldridge, M. A., Stone, K. R., Sweeney, M. H., & Bower, T. G. R. (2000). Preverbal children with autism understand the intentions of others. *Developmental Science*, *3*, 294–301.

Baron-Cohen, S. (1989). Joint-attention deficits in autism: Towards a cognitive analysis. *Development and Psychopathology*, *1*, 185–189.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind*. Cambridge, MA: The MIT Press.

Baron-Cohen, S. (2001). Theory of mind and autism: A review. In G. L. Masters (Ed.), *International review of research in mental retardation: Autism vol. 23* (pp. 169–184). San Diego, CA: Academic Press.

Behne, T., Carpenter, M., & Call, J. (2005). Unwilling versus unable: Infants' understanding of intentional action. *Developmental Psychology*, *41*, 328–337.

Bellagamba, F., & Tomasello, M. (1999). Re-enacting intended acts: Comparing 12 and 18 month olds. *Infant Behavior and Development*, *22*, 277–282.

Bernabei, P., Camaioni, L., & Levi, G. (1998). An evaluation of early development in children with autism and pervasive developmental disorders from home movies: Preliminary findings. *Autism*, *2*, 243–258.

Berument, S. K., Rutter, M., Lord, C., Pickles, A., & Bailey, A. (1999). Autism screening questionnaire: diagnostic validity. *The British Journal of Psychiatry*, *175*, 444–451.

Carpenter, M., Akhtar, N., & Tomasello, M. (1998a). Fourteen through 18-month-old infants differentially imitate intentional and accidental actions. *Infant Behavior and Development*, *21*, 315–330.

Carpenter, M., Nagell, K., & Tomasello, M. (1998b) Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63*(4), 176 pp.

Carpenter, M., Pennington, B. F., & Rogers, S. J. (2001). Understanding of others' intentions in children with autism. *Journal of Autism and Developmental Disorders*, *31*, 589–599.

Charman, T., Swettenham, J., Baron-Cohen, S., Cox, A., Baird, G., & Drew, A. (1997). Infants with autism: An investigation of empathy, pretend play, joint attention, and imitation. *Developmental Psychology*, *33*, 781–789.

D'Entremont, B., Yazbek A., Morgan, A., & MacAulay, S. (2006). Early gaze following and the understanding of others. In R. Flom, K. Lee, & D. Muir (Eds.). *The ontogeny of gaze processing in infants and children* (pp. 77–93). Baltimore: Lawrence Erlbaum Associates, Inc.

Fombonne, E. (2003). Epidemiological surveys of autism and other pervasive developmental disorders: an update. *Journal of Autism and Developmental Disorders*, *33*, 365–382.

Hill, E. L. (2004). Evaluating the theory of executive dysfunction in autism. *Developmental Review*, *24*, 189–233.

Huang, C., Heyes, C., & Charman, T. (2002). Infants' behavioral reenactment of "failed attempts": Exploring the roles of emulation learning, stimulus enhancement, and understanding of intentions. *Developmental Psychology*, *38*, 840–855.

Huang, C., Heyes, C., & Charman, T. (2006) Preschoolers' behavioural reenactment of 'failed attempts': The roles of intention-reading, emulation and mimicry. *Cognitive Development, 21*(1), 36–45.

Hughes, C., Russell, J., & Robbins, T. W. (1994). Evidence for executive dysfunction in autism. *Neuropsychologia*, *32*, 477–492.

Leekam, S., Baron-Cohen, S., Perrett, D., Milders, M., & Brown, S. (1997). Eye-direction detection: A dissociation between geometric and joint attention skills in autism. *British Journal of Developmental Psychology*, *15*, 77–95.

Lopez, B. R., Lincoln, A. J., Ozonoff, S., & Lai, Z. (2005). Examining the relationship between executive functions and restricted, repetitive symptoms of autistic disorder. *Journal of Autism and Developmental Disorders*, *35*, 445–460.

Lovaas, O. I. (2003). *Teaching individuals with developmental delays: Basic intervention techniques*. Austin, TX: Pro-Ed.

Meltzoff, A. M. (1995). Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children. *Developmental Psychology*, *31*, 838–850.

Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders*, *20*, 115–128.

Mundy, P., Sigman, M., & Kasari, C. (1992). Nonverbal communication, affective sharing, and intersubjectivity. *Infant Behavior and Development*, *15*(3), 377–381.

Mundy, P., & Willoughby, J. (1996). Nonverbal communication, joint attention, and social emotional development. In M. Lewis, & M. Sullivan (Eds.), *Emotional development in atypical children* (pp. 65–87). New York: Wiley.

Olineck, K. M., & Poulin-Dubois, D. (2005). Infants' ability to distinguish between intentional and accidental actions and its relation to internal state language. *Infancy*, *8*, 91–100.

Osterling, J., & Dawson, G. (1994). Early recognition of children with autism: A study of first birthday home videotapes. *Journal of Autism and Developmental Disorders*, *24*, 247–257.

Osterling, J. A., Dawson, G., & Munson, J. A. (2002). Early recognition of 1-year-old infants with autism spectrum disorder versus mental retardation. *Development and Psychopathology*, *14*, 239–251.

Perry, A., Condillac, R. A., Freeman, N. L., Dunn-Geier, J., & Belair, J. (2005). Multi-site study of the Childhood Autism Rating Scale (CARS) in five clinical groups of young children. *Journal of Autism and Developmental Disorders*, *35*, 625–634.

Phillips, W., Baron-Cohen, S., & Rutter, M. (1998). Understanding intention in normal development and in autism. *British Journal of Developmental Psychology*, *16*, 337–348.

Rogers, S., Cook, I., Young, G., & Giolzetti, A. (2005). *Imitation of instrumental versus non-instrumental actions in young children with autism.* Paper presented at the International Meeting for Autism Research, Boston.

Rogers, S. J., Hepburn, S. L., Stackhouse, T., & Wehner, E. (2003). Imitation performance in toddlers with autism and those with other developmental Disorders. *Journal of Child Psychology and Psychiatry*, *44*, 763–781.

Rogers, S., & Pennington, B. F. (1991). A theoretical approach to the deficits in infantile autism. *Development and Psychopathology*, *3*, 137–162.

Russell, J., & Hill, E. L. (2001). Action-monitoring and intention reporting in children with autism. *Journal of Child Psychology and Psychiatry*, *42*, 317–328.

Schopler, E., Reichler, R. J., & Renner, B. (1988). *The childhood autism rating scale* (*CARS*). Los Angeles, CA: Western Psychological Services.

Smith, I. M., & Bryson, S. E. (1994). Imitation and action in autism: A critical review. *Psychological Bulletin*, *116*, 259–273.

Smith, I. M., & Bryson, S. E. (1998). Gesture imitation in autism I: Nonsymbolic postures and sequences [Special issue]. *Cognitive Neuropsychology*, *15*, 747–770.

Tomasello, M. (1995). Joint attention as social cognition. In C. Moore, & P. J. Dunham (Ed.), *Joint attention: Its origins and role in development* (pp. 103–130). Hillsdale, NJ England: Lawrence Erlbaum Associates Inc.

Tomasello, M. (1999). Social cognition before the revolution. In P. Rochat (Ed.), *Early social cognition: Understanding others in the first months of life* (pp. 301–314). Mahwah, NJ: Lawrence Erlbaum Associates.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, *28*, 675–735.

Tomasello, M., Kruger, A. C., & Ratner, H. H. (1993). Cultural learning. *Behavioral and Brain Sciences*, *16*, 495–552.

Werner, E., Dawson, G., Osterling, J., & Dinno, N. (2000). Brief report: Recognition of autism spectrum disorder before one year of age: A retrospective study based on home videotapes. *Journal of Autism and Developmental Disorders*, *30*, 157–162.

Wetherby, A. M., Prizant, B. M., & Hutchinson, T. A. (1998). Communicative, social/affective, and symbolic profiles of young children with autism and pervasive developmental disorders. *American Journal of Speech-Language Pathology*, *7*, 79–91.

Wetherby, A. M., Woods, J., Allen, L., Cleary, J., Dickinson, H., & Lord, C. (2004). Early indicators of autism spectrum disorder in the second year of life. *Journal of Autism and Developmental Disorders*, *34*, 473–493.

Woods, J. J., & Wetherby, A. M. (2003). Early identification of and intervention for infants and toddlers who are at risk for autism spectrum disorder. *Language, Speech and Hearing Services in Schools*, *34*, 180–193.

Williams, J. H. G., Whiten, A., & Singh, T. (2004). A systematic review of action imitation in autistic spectrum disorder. *Journal of Autism and Developmental Disorders*, *34*, 285–299.

Zimmerman, I. L., Steiner, V. G., & Pond, R. L. (1992). *Preschool language scale-3*. San Antonio, TX: The Psychological Corporation.