Original Article

Autism
2017, Vol. 21(1) 83–91

DOI: 10.1177/1362361315627135
aut.sagepub.com
SAGE

Young children with autism spectrum disorders imitate in the context of others' prior intention

Chi-Tai Huang, Chung-Hsin Chiang and Chao-Yi Hung

Abstract

Many studies have shown that children with autism spectrum disorder have some understanding of intentions behind others' goal-directed actions on objects. It is not clear whether they understand intentions at a high level of abstraction reliant on the context in which the actions occur. This study tested their understanding of others' prior intentions with typically developing and developmentally delayed children. We replicated Carpenter et al.'s test of the ability to understand prior intentions embedded in the social situation with an additional context of no prior intention. Results showed that when the experimenter's intention was made known before the demonstration, children without autism spectrum disorder performed not only better than the autism spectrum disorder children but also better than themselves when there was no information about prior intention. No between-condition difference was found in the autism spectrum disorder group. It thus appears that children with autism spectrum disorder have difficulty decoupling intentions from the context of the situation. The present findings, together with previous evidence for the intactness of the ability to understand and to imitate goal-directed actions, suggest that asymmetrical imitation performance occurs at different levels of understanding of intention by children with autism spectrum disorder.

Keywords

autism spectrum disorder, imitation, intention, prior intention

Introduction

Since Leo Kanner (1943) first described autism, imitation was for a long time thought to be impaired in children with autism (DeMyer et al., 1972; Ritvo and Provence, 1953; Rogers et al., 1996; Smith, 1998; Williams et al., 2004). However, more recent studies showed that imitation is not globally impaired in autism (see Hamilton, 2009; Vivanti and Hamilton, 2013, for reviews). For example, children with autism are able to imitate goal-directed actions on objects (e.g. Hamilton et al., 2007) but have more difficulty when copying meaningless actions (Stone et al., 1997) or unnecessary action styles with which goal-directed actions are performed (Hobson and Lee, 1999).

What might be implicated in the intact ability to imitate actions on objects? There is a growing consensus that this reflects unimpaired abilities in goal understanding. A number of studies capitalizing on the behavioral reenactment procedure (Meltzoff, 1995) have been influential in generating this consensus (Aldridge et al., 2000; Berger and Ingersoll, 2014; Carpenter et al., 2001; Colombi et al., 2009; D'Entremont and Yazbek, 2007). In the behavioral reenactment procedure, infants observe an adult model apparently attempting but failing to perform a specific target action. Like typically developing (TD) infants, young children with autism produced a similar proportion of target acts following the behavioral reenactment procedure. Because the end state of the object is not observed, this effect has been interpreted as indicating the ability to understand and infer goal-directed intentions.

However, new evidence has challenged whether infants necessarily view others' failed attempts as being about intentions. Behavioral reenactment data may be interpreted as

National Chengchi University, Taiwan

Corresponding author:
Chi-Tai Huang, Department of Psychology, National Chengchi University, No. 64, Sec. 2, Zhinan Rd., Wenshan District, Taipei 11605, Taiwan.
Email: ucjtchu@nccu.edu.tw

non-imitative learning. For example, Huang et al. (2002, 2006) showed that TD infants and preschoolers reproduced as many target acts in the behavioral reenactment procedure (e.g. seeing a person unsuccessfully attempt to drape a loop over a peg) as when confronted with end results only (e.g. seeing the loop on the peg). According to Gibson (1988), children actively explore the environment with their discovery of the perceptual features specifying the properties of objects that elicit actions (i.e. affordances). Affordances provide information about what actions can be done with objects. When observing the end result, infants are exposed to the affordance characterizing the object's end configuration (e.g. the peg affords supporting). It is likely that they recreate the end state by detecting the relevant affordance. Similarly, affordance learning could operate in the behavioral reenactment procedure when manipulation of the target-relevant parts of the object highlights the affordance to emulate. Huang and Charman (2005) showed 17-month-old infants a modified video that included only object movements extracted from a model's unsuccessful attempts (e.g. seeing a self-propelled loop move toward and then drop near the hook). Infants in this "ghost" condition reproduced the target act as often as infants who saw the target act fully presented by the model. This suggests that the object movement pattern displayed in the failed attempts shed light on the affordance relevant to the target act. Since infants could independently learn about the target act through affordance detection, it is open to challenge whether behavioral reenactment of intended acts depends on the model's bodily acts as clues to intentions.

To clarify whether children see intentions as mental states in their imitation of other people's goals, developmentalists have recently shifted the focus of research to prior experiences that inform children about a model's mental plan to perform an action before seeing the demonstration. This notion of "prior intention," according to Searle (1983), differs from the notion of "intention in action" immanent in the model's ongoing act. There is evidence that young children benefit from others' prior intentions (Carpenter et al., 2002) when imitating how to solve a causal task. First, Carpenter et al. (2002) showed 2-year-olds how to open a box by pulling out a pin and lifting a door. Before this demonstration, some children witnessed the already-opened box (Prior: End State condition), some watched the demonstrator attempt but fail to open the box (Prior: Failed Attempt condition), and some saw her open three different containers (Prior: Context condition). These three groups of children solved the task more successfully than those who watched the demonstrator manipulate the box with irrelevant actions as the prior event (No Prior: Irrelevant Action condition) or who simply saw the demonstration only (No Prior: No Predemo condition). A recent study by Huang (2013) expanded the Prior: Context condition of Carpenter et al.'s (2002) study by presenting the end state of a substantially different box as information about prior intention and found the facilitating effects of prior intention were not reliant on the perceptual similarity between the predemonstration and demonstration apparatuses. The author also ruled out the possibility that the predemonstration apparatus afforded an idea that boxes open. Young children continued to benefit from prior intention when the predemonstration apparatus was replaced with a functionally different task (using a stick to retrieve the reward from a trap tube).

In this study, we set out to replicate and extend the Prior: Context condition used by Carpenter et al. (2002) with autism spectrum disorder (ASD) children and comparison peers of developmentally delayed (DD) and TD children. We consider this condition to be a more stringent test of young children's ability to consider intentions as mental states in the social learning of a problem-solving task, as they are required to transfer their understanding of a person's intention shown in the predemonstration to a new task that differs both in appearances and in the mechanism for retrieving the reward. A second extension was to modify the No Prior: Irrelevant Action condition of Carpenter et al.'s (2002) study based on the context of the situation. This condition exposed children to a predemonstration consisting of unintentional object-oriented actions. Following the experimenter's prior behavior, children in both conditions watched the actor demonstrate a two-step action to complete the goal of the target task. If the ability to imitate goal-directed actions in autism reflects some understanding of goals in relation to mental states, children with ASD should be more successful in retrieving the reward in the Prior Intention than in the No Prior Intention condition as do children without ASD. However, if children with ASD are able to understand intentions immanent in a person's behavior but have specific difficulty in understanding prior intentions as was shown in previous research using a verbal judgment method (Misailidi, 2005; Phillips et al., 1998), they should perform more poorly than children without ASD in the Prior Intention condition, with no difference between groups in the No Prior Intention condition.

Methods

Participants

Three groups of children took part in this study: (1) 24 children with ASD (19 males) comprising 17 children with autistic disorder and 7 children with pervasive developmental disorder not otherwise specified (PDD-NOS) diagnosed according to *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; DSM-IV; American Psychiatric Association, 2000) criteria, (2) 16 DD children without autism (12 males) including 9 children with idiopathic developmental delay and 7 children with speech delay, and (3) 24 TD children (15 males). This study was conducted

Table 1. Characteristics of participants in each group by condition.

Participants	ASD		DD		TD		Significance (Kruskal–Wallis), *p* value
Measure	Prior Intention (*n* = 12)	No Prior Intention (*n* = 12)	Prior Intention (*n* = 8)	No Prior Intention (*n* = 8)	Prior Intention (*n* = 12)	No Prior Intention (*n* = 12)	
CA (months)	47.08 (7.55)	44.75 (10.86)	43.63 (13.51)	44.38 (16.72)	26.92 (2.68)	27.00 (3.36)	<0.001
NVMA (months)	31.29 (7.59)	30.33 (7.50)	39.31 (10.85)	35.06 (17.02)	29.79 (3.65)	32.38 (6.82)	0.335
VMA (months)	29.63 (7.51)	25.29 (7.80)	31.00 (7.54)	29.25 (9.82)	30.75 (3.90)	32.08 (7.99)	0.382
Autism severity	14.08 (3.50)	14.00 (3.02)	3.25 (2.19)	2.88 (1.55)	–	–	<0.001

ASD: autism spectrum disorder; TD: typically developing; DD: developmentally delayed; CA: chronological age; NVMA: non-verbal mental age; VMA: verbal mental age.

under the approval of the institutional review board at the Chang Gung Hospital in Taiwan. Parents gave written consent for their children's participation after being informed about the purpose of the study. Recruitment was carried out through Internet advertising, by word-of-mouth, or through referral from child psychiatric or pediatric physicians. All participants were ethnic Chinese living in northern Taiwan. Two additional children with ASD were tested but not included in the final sample due to a lack of interest in the task.

ASD diagnoses were confirmed by a research team conducting a comprehensive assessment procedure, including the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000, 2002), Autism Diagnostic Interview—Revised (ADI-R; Lord et al., 1994), and clinical judgment. The children's verbal mental age (VMA) and non-verbal mental age (NVMA) were calculated from their scores on the Mullen Scales of Early Learning (MSEL; Mullen, 1995): VMA consisted of the average of their scores on the Language Expressive and Language Receptive Organization Scales and NVMA consisted of the average of their scores on the Visual Receptive Organization and Fine Motor Scales (see Rogers et al., 2003). Table 1 summarizes the characteristics of participants from each group by condition. Although the chronological age (CA) of TD children was relatively young, there were no significant differences in either NVMA or VMA as a function of group and condition. All children with ASD scored above the cutoff for either autism (12) or autism spectrum (8–11) from Module 1 or 2 of the ADOS based on the child's expressive language level. All DD children scored below 7 on the ADOS. In addition, the DD children either had a T score below 40 on any subscale from VMA or had an overall MSEL developmental quotient (DQ) score below 85. TD children were screened for ASD concerns using the Social Communication Questionnaire (SCQ; Rutter et al., 2003).

Materials

Three opaque containers, each of which had a toy inside, were used to present the experimenter's goal before the demonstration in the Prior Intention condition. The first was a bucket with a lid (10 cm high and 9.5 cm in diameter) that could be opened by pressing a pedal extending from its bottom. The second was a ring-shaped receptacle (9.5 cm high and 22 cm in diameter) that could be opened by pulling the upper lid apart. The third was a lunch box ($12 \times 10 \times 5.5$ cm) that could be opened by unlocking the side latches. Three objects, all of which had no lid, were used to present unintentional irrelevant actions before the demonstration in the No Prior Intention condition. They were as follows: a cube storage bin ($6 \times 6 \times 7$ cm), a flying disk (11 cm in diameter), and a rectangular block ($16 \times 8 \times 4$ cm).

The apparatus (Figure 1) used in the demonstration was a replica of the birdhouse (Huang, 2013), which was adapted from the one originally developed by Carpenter et al. (2002). It measured 30 cm × 30 cm × 45 cm, consisting of an exterior door and an interior door. The exterior door could be opened by pulling up a knob at the bottom; the interior door could be opened by pulling out a wooden pin on the left side of the birdhouse. A small toy was placed behind the interior door unseen by children. The toy could be reached when both doors were open.

Design

Participants from each of the three groups were randomly assigned to either the Prior Intention or the No Prior Intention condition. In both conditions, all participants were allowed to watch the experimenter demonstrate how to reach the reward from the birdhouse, but they were situated within different contexts before watching this demonstration. A between-subject design was a stronger experimental test because the children had only one chance to retrieve the reward. In a within-subject design, anything the experimenter produced intentionally before the demonstration could be potentially informative about prior intention. Although a between-subject design helped to eliminate carryover effects, it resulted in a reduced sample size within a condition. In order to increase the power of the analysis, the data for the DD and TD groups were

Figure 1. The experimental apparatus.

collapsed into a combined comparison group if they did not differ in the measurement of concern.

Procedure

All participants were tested in a quiet room in a university laboratory or in their daycare. In order to avoid potential cues about prior intention arising from the context of the situation, the assessment measures and experimental task were completed in two separate days. The experimental session was videotaped for later scoring.

In the Prior Intention condition, children watched the experimenter interact intentionally with three containers and then with the birdhouse. This condition was designed for children to attribute a general goal to the experimenter before seeing how to open the birdhouse. The three containers were arranged in a row. She first went to the bucket, said "Look!" to engage the child, opened the lid, and ended up extracting the toy. After a brief display, she put the toy back in the bucket and closed it. She dealt with the ring-shaped receptacle and the meal box using the same procedure. After the prelude, she went on to the birdhouse and proceeded to present the demonstration. She pulled up the door knob so that the exterior door was opened. Next, she opened the interior door by pulling out the wooden pin. When the experimenter was pulling out the pin, the child could see the interior door slide aside through the opening at the front. She took out the toy, displayed it briefly, put it back in the birdhouse, and reset the apparatus unseen by the child (using a tablecloth). Finally, she invited the child to play with the birdhouse by saying, "Now, it's your turn." Children were given 30 s to explore the birdhouse, timed from when they first touched it.

In the No Prior Intention condition, by contrast, the experimenter showed children the predemonstration in an unintended manner. She manipulated three objects using actions unrelated to opening the birdhouse. She said "Look," raised the cubic bin, rotated it 90° counterclockwise, and placed it on the floor. Next, she knocked the disk three times using her index finger and then dragged the block along the floor twice. Finally, the experimenter moved onto the birdhouse and demonstrated the task solutions to which the children in the Prior Intention condition were exposed.

Scoring

The third author (C.-Y.H.) coded each videotaped session. An undergraduate student blind to the hypotheses of this study coded 30% of the videotapes. Both coders noted whether or not children reproduced two demonstrated components during the 30-s period: (1) open the exterior door by pulling up the knob, and (2) open the interior door by pulling out the pin. Agreement was 100% for both pull-pin and pull-knob components.

Results

Figure 2 shows the percentages of children who successfully retrieved the reward from the birdhouse within a 30-s response period. Preliminary analyses showed that the DD and TD groups did not differ in either condition,

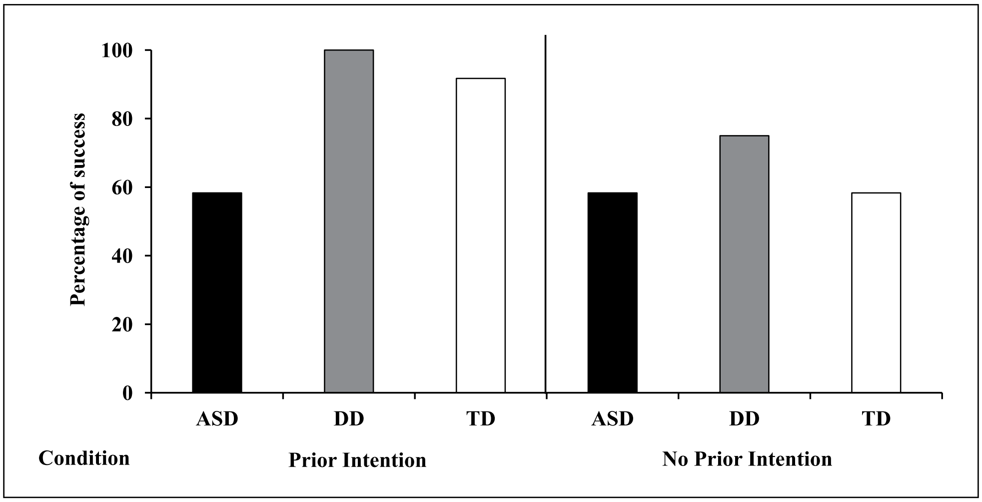

Figure 2. Percentages of children from each group who succeeded at retrieving the reward in each condition.

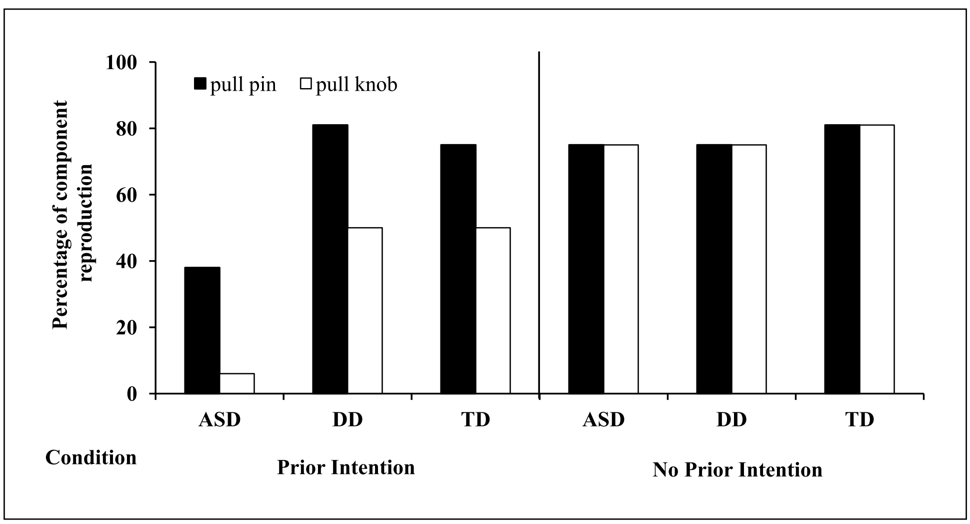

Figure 3. Percentages of children from each group who reproduced each solution component as demonstrated in each condition.

both Fisher tests, *ns*. The data for the two groups were thus collapsed into a combined comparison group for each condition. A 4×2 contingency chi-square test comparing the number of participants who succeeded or failed showed significant differences among children with ASD and children without ASD in the Prior Intention and No Prior Intention conditions, Fisher test, $p=0.026$. Planned comparisons for between-group differences within each condition indicated that children without ASD (19 of 20) outperformed children with ASD (7 of 12) in the Prior Intention condition, Fisher test, $p=0.018$, one-tailed, but they did not differ in the No Prior Intention condition, Fisher test, *ns*. That the facilitating effect of prior intention was specific to the performance of children without ASD was confirmed by planned comparisons showing their better performance in the Prior Intention condition than in the No Prior Intention condition (13 of 20), Fisher test, $p=0.022$, one-tailed, but no between-condition difference for children with ASD, Fisher test, *ns*. The mean (standard deviation) latencies to success in the Prior Intention and No Prior Intention conditions were, respectively, as follows: ASD, 13.42 s (3.69) and 14.58 s (6.06); TD and DD combined, 14.58 s (5.72) and 13.61 s (6.28). A Kruskal–Wallis test of the mean latencies yielded no differences as a function of group and condition, $\chi^2(3, N=46) < 1$.

We next examined whether success resulted from reproducing a particular kind of solution component. Figure 3 presents the percentages of children who reproduced the pull-pin or pull-knob component. Preliminary analyses showed that the DD and TD groups reproduced either of the two components at similar rates in each condition, all Fisher tests, *ns*. We thus collapsed the data for the two groups, respectively, in each condition. There were no

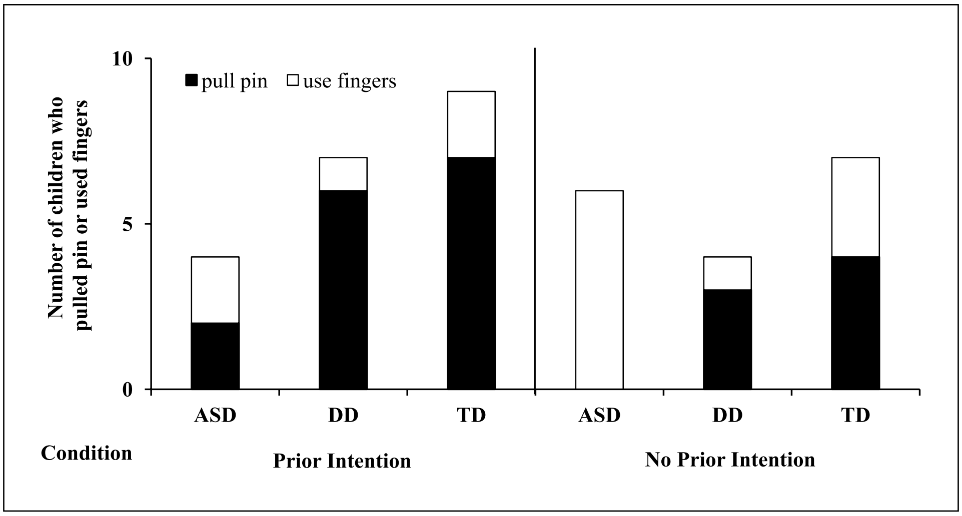

Figure 4. Numbers of children who, after opening the exterior door, opened the interior door by reproducing pull-pin or sliding the door with their fingers.

significant differences in the rate of reproductions with pull-pin among children with ASD and children without ASD in the Prior Intention and No Prior Intention conditions, Fisher test, *ns*. Although children with ASD appeared to have a relatively low rate of reproductions with pull-knob in the Prior Intention condition, differences fell just below significance, Fisher test, $p = 0.074$.

It should be noted that, when children first pulled the exterior door open, they could open the interior door either by imitation (pulling the pin) or by emulation (sliding aside the door using their fingers). A total of 22 of the 32 successful children from the combined comparison group and 10 (of 14) from the ASD group began with the exterior door. Figure 4 presents the numbers of these children who, after opening the exterior door, used an imitation or emulation strategy to open the interior door. Although relatively few children with ASD succeeded in the task, they all used the emulation strategy in the No Prior Intention condition. To explore any potential effects of the group, we combined the data across conditions to compensate for the modest sample size. Overall, children from the ASD group (8 of 10) were more likely to use fingers to slide the interior door than children from the combined comparison group door (5 of 22), Fisher test, $p = 0.005$.

Discussion

Previous research has shown that a model's prior intention facilitates 2-year-olds' observational learning of a causal task (Carpenter et al., 2002). In this study, we investigated whether children with autism can make sense of others' prior intentions by replicating Carpenter et al.'s (2002) Prior: Context condition with TD and DD children. The results found that when given a chance to know the experimenter's intention before the demonstration, the comparison children not only performed better than the ASD group but also outperformed themselves when the prelude consisted of meaningless irrelevant actions. By contrast, the ASD group exhibited similar performance on the task across conditions. Here, we explore some possible explanations for this result.

First, we can rule out either VMA or NVMA as explanations, given that the groups were matched on these variables. It should be noted that the DD group was actually superior to the TD group (but not to the ASD group) on the Fine Motor Subscale of the MSEL. Given that the two comparison groups showed similar levels of success, if difference in fine motor skills serves as a general explanation, they should have performed better than the ASD group across conditions and not just in the Prior Intention condition. Similarly, there were no group differences in reproduction of each solution component, and memory problems alone cannot account for the poorer performance of the ASD group. The difference is also unlikely to be due to affordance learning, because the appearances of the containers and the actions used to present the predemonstration differed greatly from those involved in the target demonstration. This did not permit children to explore the mechanics of the main task or relevant motor patterns before the demonstration. Children with ASD actually displayed some evidence of emulation. Instead of imitating pull-pin, they were overall more likely than the comparison children to move the interior door with fingers, suggesting a susceptibility to the affordances of the task. Nonetheless, they did not benefit from the use of an emulation strategy despite it being even stronger in the No Prior Intention condition.

Could overimitation account for the current results? In overimitation, children faithfully copy causally irrelevant actions in goal-directed action sequences (e.g. Horner and

Whiten, 2005; Lyons et al., 2007), indicating a social affiliation with another person (Marsh et al., 2014; Nielsen and Blank, 2011; Over and Carpenter, 2012). Given that children with autism do not overimitate (Marsh et al., 2013), it may be that children without ASD tested here were overimitating without understanding of the model's prior intention. We deem this explanation unlikely, because the demonstration of opening the box did not include any unnecessary components. Overimitation could not be adequately addressed in this study. In addition, there is already some evidence showing that when a style component was added to the demonstration, children who knew the model's prior intention were more likely to skip the unnecessary style than those who did not (Carpenter et al., 2002). Similarly, when children knew the goal of action sequences before the demonstration, they were more likely to exhibit a reduction in overimitation (Williamson and Markman, 2006). If the superior performance by children without ASD in the Prior Intention condition was due to overimitation, they should have also performed equally well in the No Prior Intention condition.

It might be argued that the good performance of the comparison group in the Prior Intention condition did not require the understanding of the experimenter's prior intention (i.e. seeing the containers open might simply lend themselves the idea that boxes open). In other words, although the predemonstration did not familiarize children with the affordances involved in opening the birdhouse, it is possible that being aware of the general affordance allowed them to generalize their learning about outcomes (rather than intentions) across different task materials. Contrary to this, there is now evidence that children continue to benefit from prior intention even if the predemonstration apparatus is not box-shaped and the method of accessing the reward is not based on opening systems (Huang, 2013). This finding leads us to believe that children without ASD were not merely guided by the physical outcomes of the predemonstration but were engaged in interpreting the experimenter's previous actions with the containers as her general goal within the context.

However, it is less clear why children with ASD performed less well in the Prior Intention condition. One possibility immediately suggesting itself is that they have difficulty in understanding the concept of prior intention as mental entities. Consistent with this explanation, previous research has reported similar deficits for older children with ASD when they need to answer explicit verbal questions (Misailidi, 2005; Phillips et al., 1998). It should, however, be noted that, given the well-documented problems in generalization, it remains to be shown whether their strong tendency to focus on episodic details might detract from generalizing between the predemonstration and the main task. That is, children with ASD did not benefit from the model's prior intention, perhaps because they had difficulty generalizing the model's goal across various containers and perceptually distinct actions. The natural pedagogy theory proposed by Csibra and Gergely (2009) lends support to this idea. The claim is that ostensive social cues (such as gaze, pointing gesture, and infant-directed speech) lead children to generalize specific actions and interpret the information as generalizable and kind-relevant. Since children with ASD have difficulties with social processing (e.g. Dalton et al., 2005; Dawson et al., 2004; Tager-Flusberg, 2010), they may find it more difficult to see relationships between contexts and abstract something generalizable such as prior intention.

We do not wish to overextend the facilitating effect of prior intention on imitation to an explicit representation of intention. Rather, it is notable that imitation does not require making explicit conceptual and linguistic knowledge that might be already represented but less accessible and thus provides an implicit non-verbal test that can be used to pose such questions in young children. However, there appears to be a gap between explicit and implicit understanding of others' intentions. Whereas this study and others (Carpenter et al., 2002; Huang, 2013) suggest that understanding of prior intentions might be present in 2- to 3-year-olds in social learning situations, children cannot answer explicit verbal questions about prior intentions until 5–6 years of age (Astington, 1991). Similarly, while there is evidence that 14- to 18-month-old infants preferentially imitate intentional over accidental actions (Carpenter et al., 1998), 4-year-olds have difficulty judging intentions when actions produce unintended (by accident) but desirable outcomes (Liao et al., 2011). Therefore, we must be cautious about extending the superior performance by children without ASD in the Prior Intention condition to a full-fledged concept of intention.

The finding that children with ASD have difficulty decoupling intentions from the context of the situation does not necessarily conflict with the substantial literature on their ability to understand object-oriented goal-directed intentions (e.g. Aldridge et al., 2000; Berger and Ingersoll, 2014; Carpenter et al., 2001). We interpret these findings as their asymmetrical understanding of "intention in action" and "prior intention" (Searle, 1983). It is plausible that, for example, autistic children are capable of comprehending intentions behind the model's actions in the behavioral reenactment task, because during observation of the failed attempts, they also watch the object movements that evoke the object affordances to emulate (Huang and Charman, 2005; Huang et al., 2002, 2006), whereas prior intention requires them to consider the model's goal in relation to the context (rather than the goal or outcome of the action per se). Although, there is debate over whether the behavioral reenactment data may well be characterized better as a non-intentional understanding of objects, learning about affordances, for our part, does not always divert from the use of intentions to guide imitation. Some recent evidence indicates that the clarity of the affordances of a task can guide infants to attribute goals to the model's bodily changes and allow them to emulate the objects' end results (Huang, 2012). In the Prior Intention condition of this study where object affordances are not counted as assets, children with autism do not benefit from contextual information. We interpret this as showing that they do not look beyond the action itself and see it as something that sheds light on one's general purpose in the context of the situation. In support of this, a recent study (Somogyi et al., 2013) has found that children with ASD do have difficulties in identifying the same action embedded in different contexts as associated with different intentions. Unlike their TD peers, who copy the novel head-touching action after seeing the model deliberately perform it (by placing her free hands visibly on the table) rather than after seeing her have to use the head because of some constraints (hands occupied with a blanket), children with ASD reproduced this unconventional action with relatively high frequency in both contexts. This suggests that they did not consider the hands-free context as signaling to them that the model intended and expected them to act in such a manner.

The current results provide some insight into a recent model that views the failure to imitate in autism as deficits in top-down selection and control processes (Southgate and Hamilton, 2008). Their claim is that imitation requires not only an understanding of goals based on visual analyses of the observed actions but also the use of social and communicative cues to decide when and what to imitate. In other words, the notion of goal immanent in imitation implements a motivation to reproduce and share the same goal of the communicative partner. The findings reported here suggest that the failure to benefit from prior intention reflects not only children with ASD's insensitivity to these cues but also their lack of motivation to know what one wants to do in the future.

In conclusion, this study suggests the need for caution in interpreting the ability to understand others' intentions in autism. Our design does not allow us to tease apart whether children with ASD's failure to benefit the model's prior intention is due to a lack of attention to social-communicative cues or impaired intention mentalizing at a higher level of abstraction. This should be an agenda for future research. One avenue for future work will be to see what factors are crucial in facilitating or hindering the transfer of a person's goal learned in one context to another context. Indeed, if atypical patterns of imitation are related to a reduced sensitivity to social-communicative cues, should an increased sensitivity not go into reverse and enhance imitation? It is also helpful to clarify the extent to which imitative proclivity in autism is susceptible to a variety of social cues recently discussed in the literature on social learning (Koenig and Sabbagh, 2013). The value of prior experience is to provide a promising paradigm for parsing different levels of intention reading in social learning contexts.

Acknowledgements

We are grateful to Dr Hsing-Chang Ni for help in completing the ethical approval application at Chang Gung Hospital and thank the children and parents who participated in this study.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

Aldridge MA, Stone KR, Sweeney MH, et al. (2000) Preverbal children with autism understand the intentions of others. *Developmental Science* 3: 294–301.

American Psychiatric Association (2000) *Diagnostic and statistical manual of mental disorders* (4th ed., text revision). Washington, DC: American Psychiatric Association.

Astington JW (1991) Intention in the child's theory of mind. In: Frye D and Moore C (eds) *Children's Theory of Mind: Mental States and Social Understanding*. Hillsdale, NJ: Erlbaum, pp. 157–172.

Berger NI and Ingersoll B (2014) A further investigation of goal-directed intention understanding in young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders* 44: 3204–3214.

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

Carpenter M, Call J and Tomasello M (2002) Understanding "prior intentions" enables 2-year-olds to imitatively learn a complex task. *Child Development* 73: 1431–1441.

Carpenter M, Pennington BF and Rogers SJ (2001) Understanding of others' intentions in children with autism and children with developmental delays. *Journal of Autism and Developmental Disorders* 31: 589–599.

Colombi C, Liebal K, Tomasello M, et al. (2009) Examining correlates of cooperation in autism: imitation, joint attention, and understanding intentions. *Autism* 13: 143–163.

Csibra G and Gergely G (2009) Natural pedagogy. *Trends in Cognitive Sciences* 13: 148–153.

Dalton KM, Nacewicz BM, Johnstone T, et al. (2005) Gaze-fixation and the neural circuitry of face processing in autism. *Nature Neuroscience* 8: 519–526.

Dawson G, Toth K, Abbott R, et al. (2004) Early social attention impairments in autism: social orienting, joint attention, and attention to distress. *Developmental Psychology* 40: 271–283.

DeMyer MK, Alpern GD, Barton S, et al. (1972) Imitation in autistic, early schizophrenic, and non-psychotic subnormal children. *Journal of Autism and Childhood Schizophrenia* 2: 264–287.

D'Entremont B and Yazbek A (2007) Imitation of intentional and accidental actions by children with autism. *Journal of Autism and Developmental Disorders* 37: 1665–1678.

Gibson EJ (1988) Exploratory behavior in the development of perceiving, acting, and the acquiring of knowledge. *Annual Review of Psychology* 39: 1–41.

Hamilton AF (2009) Research review: goals, intentions and mental states: challenges for theories of autism. *Journal of Child Psychology and Psychiatry* 50: 881–892.

Hamilton AF, Brindley RM and Frith U (2007) Imitation and action understanding in autistic spectrum disorders: how valid is the hypothesis of a deficit in the mirror neuron system? *Neuropsychologia* 45: 1859–1868.

Hobson RP and Lee A (1999) Imitation and identification in autism. *Journal of Child Psychology and Psychiatry* 40: 649–659.

Horner V and Whiten A (2005) Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal Cognition* 8: 164–181.

Huang CT (2012) Outcome-based observational learning in human infants. *Journal of Comparative Psychology* 126: 139–149.

Huang CT (2013) Contexts of a person's prior intentions facilitate observational learning in 2.5-year-old children. *Cognitive Development* 28: 374–385.

Huang CT and Charman T (2005) Gradations of emulation learning in infants' imitation of actions on objects. *Journal of Experimental Child Psychology* 92: 276–302.

Huang CT, Heyes CM and 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 CT, Heyes CM and Charman T (2006) Preschoolers' behavioural reenactment of "failed attempts": the roles of intention-reading, emulation and mimicry. *Cognitive Development* 21: 36–45.

Kanner L (1943) Autistic disturbances of affective contact. *Nervous Child* 2: 217–250.

Koenig M and Sabbagh MA (2013) Selective social learning: new perspectives on learning from others. *Developmental Psychology* 49: 399–403.

Liao Y, Li H and Deak GO (2011) Can unpredicted outcomes be intended? The role of outcome-beliefs in children's judgment of intention. *Cognitive Development* 26: 106–117.

Lord C, Risi S, Lambrecht L, et al. (2000) The autism diagnostic observation schedule-generic: a standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders* 30: 205–223.

Lord C, Rutter M and LeCouteur A (1994) Autism Diagnostic Interview—revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of Autism and Developmental Disorders* 24: 659–685.

Lord C, Rutter M, DiLavore PC, et al. (2002) *Autism Diagnostic Observation Schedule—Generic*. Los Angeles, CA: Western Psychological Services.

Lyons DE, Young AG and Keil FC (2007) The hidden structure of overimitation. *Proceedings of the National Academy of Sciences of the United States of America* 104: 19751–19756.

Marsh LE, Ropar D and Hamilton AF (2014) The social modulation of imitation fidelity in school-age children. *PLoS ONE* 9: e86127.

Marsh L, Pearson A, Ropar D, et al. (2013) Children with autism do not overimitate. *Current Biology* 23: R266–R268.

Meltzoff AN (1995) Understanding the intentions of others: reenactment of intended acts by 18-month-old children. *Developmental Psychology* 31: 838–850.

Misailidi P (2005) The concept of intention in autism: the ability of children with autism to distinguish prior intention from action and intention in action from bodily movement. *Hellenic Journal of Psychology* 2: 59–79.

Mullen EM (1995) *Mullen Scales of Early Learning*, AGS ed. Circle Pines, MN: American Guidance Service Inc.

Nielsen M and Blank C (2011) Imitation in young children: when who gets copied is more important than what gets copied. *Developmental Psychology* 47: 1050–1053.

Over H and Carpenter M (2012) Putting the social into social learning: explaining both selectivity and fidelity in children's copying behavior. *Journal of Comparative Psychology* 126: 182–192.

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

Ritvo S and Province S (1953) Form perception and imitation in some autistic children: diagnostic findings and their contextual interpretation. *The Psychoanalytical Study of the Child* 8: 155–161.

Rogers SJ, Bennetto L, McEvoy R, et al. (1996) Imitation and pantomime in high-functioning adolescents with autism spectrum disorders. *Child Development* 67: 2060–2073.

Rogers SJ, Hepburn SL, Stackhouse T, et al. (2003) Imitation performance in toddlers with autism and those with other developmental disorders. *Journal of Child Psychology and Psychiatry* 44: 763–781.

Rutter M, Bailey A and Lord C (2003) *SCQ: The Social Communication Questionnaire* (Manual). Los Angeles, CA: Western Psychological Services.

Searle JR (1983) *Intentionality: An Essay in the Philosophy of Mind*. Cambridge: Cambridge University Press.

Smith IM (1998) Gesture imitation in autism: 1. Nonsymbolic postures and sequences. *Cognitive Neuropsychology* 15: 747–770.

Somogyi E, Király I, Gergely G, et al. (2013) Understanding goals and intentions in low-functioning autism. *Research in Developmental Disabilities* 34: 3822–3823.

Southgate V and Hamilton AF (2008) Unbroken mirrors: challenging a theory of autism. *Trends in Cognitive Science* 12: 225–229.

Stone WL, Ousley OY and Littleford CD (1997) Motor imitation in young children with autism: what's the object? *Journal of Abnormal Child Psychology* 25: 475–485.

Tager-Flusberg H (2010) The Origins of social impairments in autism spectrum disorder: studies of infants at risk. *Neural Networks* 23: 1072–1076.

Vivanti G and Hamilton AF (2013) Imitation in autism spectrum disorders. In: Volkmar F, Paul R, Rogers S, et al. (eds) *The Handbook of Autism and Developmental Disorders*. New York: Wiley, pp.278–301.

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

Williamson RA and Markman EM (2006) Precision of imitation as a function of preschoolers' understanding of the goal of the demonstration. *Developmental Psychology* 42: 723–731.