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A Two Time Point Study of Imitative Abilities in Children with Autism Spectrum Disorders

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Background Researchers have used various paradigms to explore the universality and specificity of imitation deficits in children with autism spectrum disorders (ASDs). However, some issues still need to be investigated, especially for children with ASDs under the age of 4.
Method Two studies were conducted to examine the imitative abilities of children with autism spectrum disorders. Study 1 examined immediate and deferred imitation abilities in 18 children with ASDs, 18 children with developmental delay (DD), and 19 typically developing children (mean ages of all groups were below 4 years). Four tasks were used to evaluate immediate imitation abilities: meaningful actions on objects, non-meaningful actions on objects, manual movements, and oral-facial movements. Eighteen months after study 1 was completed, study 2 examined advanced imitative abilities in 11 children with ASDs and 11 children with DD from study 1.
Results The results of study 1 indicated that, compared to the two control groups, children with ASDs experienced significant difficulty in imitating non-meaningful actions only. The findings of study 2 suggested that children with ASDs were still significantly impaired on the imitation of single non-meaningful actions compared to children with DD.
Conclusions The relationships between specific imitation deficits, executive functioning, and shared intentionality in children with ASDs are further discussed.

Keywords: autism spectrum disorders, imitation, style of imitation

Introduction

Early infant imitation provides a developmental foundation for peer interaction and communication (Nadel *et al.* 1999). Imitation impairment in children with autism creates a difficult challenge in terms of social and cognitive development. Many researchers have used various paradigms to explore the universality and specificity of imitation deficits in children with autism spectrum disorders (ASDs). Some researchers have reported that children with ASDs demonstrated impairment on a variety of imitation tasks (Williams *et al.* 2004; Rogers & Williams 2006). Although imitation impairment in ASDs is well-recognized among autism researchers, some issues still need to be investigated, especially for children with ASDs under the age of 4.

Three measures are commonly used to investigate imitation abilities: actions on objects, manual and posture movements, and oral-facial movements. Actions on objects are further distinguished into meaningful and non-meaningful actions. Meaningful actions are those where the object is used in a conventional or appropriate manner (e.g. pushing a toy car along) in contrast to non-meaningful actions where objects are used in an unconventional or inappropriate manner (e.g. pushing a cup along) (Killen & Uzgiris 1981). Only three studies have focused on the issues of imitation in children below the age of four. One of these involved meaningful object imitation tasks (Stone *et al.* 1997). In that study, children with autism showed no significant impairment as compared to children with development delay or with typical development. However, studies that involved non-meaningful object imitation tasks showed that children with autism displayed significant difficulty (Stone *et al.* 1997; Rogers *et al.* 2003). Besides impairment that was observed in immediate object imitation,

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children with autism also appeared to be impaired in deferred object imitation (Dawson *et al.* 1998). In addition, to the object imitation impairments mentioned above, children with autism showed body imitation impairments, such as manual imitation (Stone *et al.* 1997) and facial/oral imitation (Rogers *et al.* 2003).

Different methodologies have been used in conducting research on object imitation. For example, when demonstrating object imitation tasks the examiner said 'please do this' in Rogers *et al.* (2003) or 'do this' or 'do what I do' in Stone *et al.* (1997). These phrases provide the child with a cue. Meltzoff (1988), used a different method that reduced hints given by the examiner's wording by using 'your turn' instead.

The objective of this study was to examine whether young children with ASDs in Taiwan, a country of Eastern culture, had the same pattern of imitation deficits as young children with ASDs in Western cultures. Participants were followed over two time points to explore their developmental trajectory in imitation which few studies have done (Stone *et al.* 1997; Hepburn & Stone 2006). Because the abnormalities in development in children with ASDs are believed to be biological in nature (Dawson *et al.* 2002), cultural differences may not influence the core deficits in their development. Therefore, we hypothesize that the Taiwanese children with ASDs will reveal imitation deficits and that the imitation impairments will be evident even at a later developmental stage. We used a procedure for the measure of imitation different from that used by Rogers *et al.* (2003) and Stone *et al.* (1997) in order to reduce hints given by the examiner's wording. In addition, early social-cognitive abilities, including imitation, joint attention, and play are believed to be interrelated and to have an important role in the development of language and social competence in both children with typical and atypical development (Rogers & Pennington 1991). However, recent studies have examined relationships between these variables and have got mixed results in individuals with autism (Stone *et al.* 1997; Roeyers *et al.* 1998; Rogers *et al.* 2003). The present study will explore these issues again.

Study 1

The purpose of study 1 was to compare immediate imitation and deferred imitation in young children with ASDs, developmental delay (DD), and typical development (TD). This investigation also examined the relationship among imitative skills, joint attention (JA) and play in children with ASDs.

Methods

Participants and procedures

Fifty-five children were recruited as participants, including 18 children with ASDs [16 cases of autism, 2 cases of pervasive developmental disorder, not otherwise specified (PDDNOS)], 18 children with DD, and 19 children with TD. All children with ASDs and DD were recruited from Chia-Yi Christian Hospital except for one child with an autism diagnosis who was referred by a psychiatrist from Chang Gung Memorial Hospital. Parents of children with ASDs and DD were invited to participate in the study. Study materials were provided and explained to parents. Parents' consent was obtained before their participation. The TD group comprised children born at the local Hospitals and they were recruited via a mail out that contained study information. Inclusion criteria were as follows: To be in the TD group, a child had to have a T score above 35 in any subscale of the Mullen Scales of Early Learning (MSEL; Mullen 1995). Children in the ASDs group were assessed and diagnosed by a multidisciplinary team according to DSM-IV (American Psychiatric Association 1994). Children in the DD group were assessed and diagnosed by the same multidisciplinary team as that for the ASDs group. To be in DD group, a child had to have a T score below 35 in any subscale of the MSEL. Children with a sensory or motor handicap were excluded from the investigation.

To match the three groups on developmental ability, the MSEL was administered. The MSEL comprises five subscales (for children ranging in age from newborn to 68 months), namely gross motor, visual reception, fine motor, receptive language, and expressive language (EL). Three sets of scores were constructed from the results of MSEL. A non-verbal mental age (NVMA) was constructed for each child via averaging the age equivalents from the visual reception and fine motor subscales. A verbal mental age (VMA) was constructed for each child by averaging the age equivalents from the receptive language and EL subscales. The overall mental age (MA) was constructed via averaging the NVMA and VMA.

One-way Analysis of Variance (ANOVA) analysis revealed that there were no significant differences among the three groups in terms of VMA or MA. As expected, one-way ANOVA demonstrated a significant difference in chronological age (CA) [F (2, 52) = 57.75, P = 0.000]. *Post hoc* comparisons using the Scheffe test demonstrated that TD children were significantly

younger than those in the two clinical groups. However, the CA of children in the ASDs and DD groups did not differ. One-way ANOVAs also showed significant differences between groups for fine motor age equivalents [F (2, 52) = 7.72, P = 0.001] and NVMA [F (2, 52) = 7.08, P = 0.002]. Furthermore, *post hoc* comparisons using the Scheffe test demonstrated that both ASDs and DD groups had significantly higher fine motor age equivalent and NVMA than the TD group. The parents of ASDs, DD, and TD groups were similar in terms of socioeconomic status [F (2, 52) = 1.75, P = 0.182] (Huang 1998). (see Table 1).

Measures

Imitation tasks. Modified from Rogers *et al.* (2003) and Stone *et al.* (1997), four tasks were used to evaluate immediate imitation abilities: meaningful actions on objects, non-meaningful actions on objects, manual movements, and oral-facial movements (see Table 2). If the task involved an object, there were two phases, the baseline and testing phases. During the baseline phase, the examiner gave the object to the child for 20 s for exploration. If the child did not perform the target action during the baseline phase, the testing phase immediately followed. During the testing phase, the examiner demonstrated the target action in front of the child, returned the object to the child, and allowed the child to play with the object for another 20 s. If the child spontaneously performed the target action during the baseline phase, an alternative target action was chosen for the testing phase. This was done to avoid the object affordance effect, i.e. actions on objects that are conventional and directly related to the functional use of the object itself. The specific administration procedure used in the present study was based on that of Meltzoff (1988); however, only three items were employed in this study instead of all six items that were described in Meltzoff's study (see Table 2). With the child looking directly at the examiner, the examiner said '(Name), look here,' and repeated the target action three times. Additionally, to avoid participants receiving hints from the spoken language of examiners, when demonstrating

Table 1 Participant characteristics of study 1

	ASDs (*n* = 18)	*DD* (*n* = 18)	*TD* (*n* = 19)
Chronological Age			
Mean[2] (SD)	40.44[1] (6.88)	38.33 (6.13)	23.26 (1.33)
Range	26–52	25–51	20–26
Non-verbal mental age			
Mean (SD)	30.42[1] (5.50)	30.47 (6.50)	24.89 (3.10)
Range	23–45.5	22.50–51	19.50–34.50
Fine Motor Equivalent			
Mean (SD)	32.06[1] (7.99)	30.56 (6.07)	24.68 (3.28)
Range	22–57	21–45	18–30
Overall mental age			
Mean (SD)	26.26 (3.92)	27.19 (5.03)	24.45 (2.29)
Range	19.75–36.25	20.25–41.5	21.25–32.5
Verbal mental age			
Mean (SD)	22.11 (3.84)	23.92 (4.10)	24 (1.85)
Range	16.50–29	18–32	22.50–30.5
Socioeconomic Status			
Mean (SD)	61.44 (19.59)	58.33 (15.56)	68.53 (15.58)
Range	38–98	35–98	49–98

[1]ASDs; DD > TD; P > 0.01; [2]Months.
SD, standard deviation; ASDs, autism spectrum disorders; DD developmental delay; TD, typical development.

Table 2 Items used in the imitation tasks of study 1

Type	*Item*
Actions on objects:	
Meaningful	Push toy car across table (Pull toy car back across table)
	Walk toy dog across table (Skip toy dog across table)
	Shake and clap tambourine (Clap tambourine on table)
Non-meaningful	Push cup across table (Put cup right-side down)
	Walk hairbrush across table (Skip hairbrush across table)
	Bang spoon on table (Press spoon to make noise)
Manual movements	Open and close both hands simultaneously
	Scratch tabletop with fingers
	Pat cheek
Oral-facial movements	Extend tongue and wiggle sideways
	Blow cotton ball across table
	Make a noisy kiss
Deferred imitation	Pull apart dumbbell toy apart (Stack the wooden bar standing on the cube)
	Use finger to press the button on the black box (Use elbow to press the button on the black box)
	Use forehead to hit the light switch (use fist to punch the light switch)

(), Alternative target action.

the imitation tasks the examiner only said to participants 'it's your turn' or 'Your turn.' The examiner never used a phrase like 'please do this' as was used in Rogers *et al.* (2003) or 'do this' or 'do what I do' as was used in Stone *et al.* (1997). The next trial was administered using the second item if the child made an imitative response to the first trial. If the child did not respond to the first trial, a second trial was administered using the same item. Up to three trials were permitted for each item.

To assess deferred imitation ability, three items selected from Meltzoff (1988) were used and the procedure was the same as that for immediate imitation but a 10 min delay was included (see Table 2). While waiting for 10 min, a five-minute Play Task (see below) was arranged for the child and then the delayed imitation materials were given in proper order to the child for manipulation. Response accuracy was scored using a three-point scale, with a passing response earning two points, an emerging response earning one point, and a failure response earning zero points. Because there were three items on each task, the score could range from 0 to 6 for each task. To determine the level of inter-rater reliability, two raters independently rated 13 (24%) of the participants' videotapes. The Cohen's kappa between the two raters was 0.85 for all the imitation items, indicating excellent agreement.

Play task. Modified from Baron-Cohen (1987) and Charman & Baron-Cohen (1997), each child was given 5 min of free play with three different sets of toys. The three sets of toys included: (i) several different stuffed animals, cars, trucks, and wooden blocks (with different shapes and sizes); (ii) a toy kitchen stove with miniature pots, pans, spoon, cups, teapot, and small green sponges and (iii) two dolls, toy telephone, toy towel, several items of cotton clothing, and a bath-tub. These three sets of toys were presented simultaneously on the floor in front of each child while a caregiver stood behind the child. During the 5 min of play time, the examiner and caregiver provided no prompting, but encouraged the child to play. For example, saying '(name), you can play with the toys' was permitted, but saying 'toy's name' or 'what to do with toys' was not permitted.

Videotapes of free play were analysed to identify occurrences of sensorimotor, relational, functional, and symbolic play based on Baron-Cohen (1987). A time-interval analysis was executed, with the play behaviour of the child being coded at 20 s intervals. To obtain inter-rater reliability, three raters independently rated 17 (31%) of the participants' videotapes. The generalizability (G) coefficients (see Shavelson & Webb 1991) were 0.93, 0.71, 0.85, and 0.95 for sensorimotor, relational, functional, and symbolic play, respectively. The play score measured in this investigation was the frequency of functional and symbolic play.

Initiating joint attention. The Early Social-Communication Scales (ESCS, Mundy *et al.* 1996) is a semi-structured, toy-based measure used to elicit non-verbal communicative behaviours, including JA, requesting, and social interaction. Because the present study is interested in studying JA, data on requesting and social interaction were not included in the current analysis. To obtain inter-rater reliability, three raters independently rated 17 (31%) of the participants' videotapes. The G coefficient was 0.90 for initiating joint attention (IJA).

Results and discussion

A multivariate analysis of variance (MANOVA) was used to determine whether the diagnostic groups differed significantly in terms of their performance on imitation tasks. The results demonstrated a significant difference existed between groups (Wilks's Lambda = 0.51, $P = 0.000$). One-way ANOVAs then demonstrated that there were significant differences in performance of non-meaningful manipulations of objects [F (2, 52) = 4.36, $P = 0.018$], but not on meaningful manipulations of objects, manual movement, oral-facial movement, deferred, or overall imitation skills. *Post hoc* comparisons using the Scheffe test demonstrated that children in the ASDs group performed significantly more poorly than those in the DD and TD groups in non-meaningful manipulations of objects (Table 3).

Results from an analysis of covariance (ANCOVA), where fine motor functioning (FM) and NVMA were covariates (Table 4), indicated significant differences on imitation of non-meaningful manipulations of objects [F (2, 50) = 7.29, $P = 0.002$] and deferred imitation [F (2, 50) = 4.47, $P = 0.012$], but not on meaningful manipulations of objects [F (2, 50) = 1.46, $P = 0.242$], manual movement [F (2, 50) = 0.39, $P = 0.679$], oral-facial movement [F (2, 50) = 0.28, $P = 0.761$], or overall imitation (total 15 items) [F (2, 50) = 1.55, $P = 0.222$]. *Post hoc* comparison demonstrated that children with ASDs performed poorer than both DD and TD children in imitation of non-meaningful manipulations of objects. The ASDs and DD children performed poorer than TD children in deferred imitation. Some TD children were too young to perform the target actions in deferred imitation. One example of this is the forehead button panel item. The target action is that the child uses his or

Table 3 Imitative skills of the three groups from study 1

	ASDs (*n* = 18)	*DD* (*n* = 18)	*TD* (*n* = 19)
Meaningful Actions on objects			
Mean (SD)	3.72 (1.90)	4.44 (1.29)	3.42 (1.39)
Non-meaningful Actions on objects			
Mean (SD)	3.17[1] (2.12)	4.61 (1.29)	4.58 (1.54)
Manual movements			
Mean (SD)	3.67 (2.20)	4.17 (1.82)	3.10 (2.08)
Oral-facial movements			
Mean (SD)	4.00 (2.14)	3.6 (1.78)	3.00 (1.70)
Deferred imitation			
Mean (SD)	2.94 (1.47)	3.06 (1.47)	3.95 (1.39)
Overall imitation (Total 15 items)			
Mean (SD)	17.39 (7.98)	19.89 (6.09)	18.05 (4.73)

[1]ASDs < DD, TD, $P < 0.05$
SD, standard deviation; ASDs, autism spectrum disorders; DD, developmental delay; TD, typical development.

Table 4 Adjusted imitative skills of the three groups from study 1[1]

	ASDs (*n* = 18)	*DD* (*n* = 18)	*TD* (*n* = 19)
Meaningful actions on objects			
Mean (SD)	3.35 (0.37)	4.28 (0.36)	3.53 (0.59)
Non-meaningful actions on objects			
Mean (SD)	2.75[2] (0.39)	4.51 (0.38)	4.46 (0.63)
Manual movements			
Mean (SD)	3.32 (0.49)	4.03 (0.48)	1.88 (0.78)
Oral-facial movements			
Mean (SD)	3.72 (0.48)	3.50 (0.47)	2.83 (0.76)
Deferred imitation			
Mean (SD)	2.89[3] (0.36)	2.83 (0.35)	4.90 (0.57)
Overall imitation (Total 15 items)			
Mean (SD)	15.90 (1.50)	19.15 (1.47)	17.60 (2.41)

[1]Adujsted for fine motor functioning and non-verbal mental age; [2]ASDs < DD, TD, $P < 0.01$; [3]ASDs, DD < TD, $P < 0.05$
ASDs, autism spectrum disorders; DD, developmental delay; TD, typical development; SD, standard deviation.

her forehead to touch a panel for activating light. Some TD children would use their hands, for example, rather than their forehead to touch the panel. This is one reason why the three groups did not differ in deferred imitation before correcting for covariance.

Table 5 revealed that, in the ASDs group, meaningful imitation, non-meaningful imitation, overall immediate imitation (total 12 items), and overall imitation (total 15 items) were significantly correlated with both FM and NVMA, while manual imitation was correlated with FM but not NVMA. Additionally, performance in meaningful imitation was significantly correlated with MA and non-meaningful imitation was significantly associated with initiating JA in the ASDs group. Among the children with DD, a significant correlation existed between meaningful imitation and EL, VMA, and MA, while overall immediate imitation was also significantly related to EL. The results failed to replicate the findings of Stone *et al.* (1997), but the relationship between overall immediate imitation and EL was consistent with the findings of Rogers *et al.* (2003). Although most of the correlations did not reach greater significance levels when multiple comparisons were used in present study (*P* level higher than 0.01 was only one), the findings of Stone *et al.* (1997) regarding the dissociation between imitation of actions on objects and imitation of body/facial movement should be interpreted with caution.

To summarize, the current study found that young children with ASDs showed impairment compared to both children with DD and TD on imitation of non-meaningful manipulations of objects. The nature of this deficit needs to be explored in future research. Hepburn & Stone (2006) suggested that different patterns of correlations exist for the different imitation tasks in a sample of two- and three- year-old children with autism. Their findings indicated that different imitation tasks may involve different social, cognitive, and motor skills in these young children. For example, both fine motor skills and attention - following were associated with the observational learning imitation task. Attention - following was also associated with structured imitation tasks. If their suggestions are true, we could expect that the more social in nature an imitation task is, the more impaired children with ASDs would be. To understand the nature of imitation impairment in children with ASDs, it will be necessary to design more social-related imitative tasks for further studies.

Study 2

Study 2 was administered 18 months after the completion of study 1. Based on the results of study 1, significant impairment on non-meaningful manipulations of objects was specific to children with ASD. For this reason, the purpose of study 2 focused on object imitation in children with ASD. To avoid any ceiling effect, we added the 2-step imitation sequence. Furthermore, to explore the social nature of actions on object imitation

Table 5 Correlation between different imitation skills and cognitive-social abilities

	FM	*NVMA*	*EL*	*VMA*	*MA*	*Play*	*IJA*
Autism Spectrum Disorder							
Meaningful imitation	0.508*	0.535*	0.070	0.194	0.488*	−0.052	0.297
Non-meaningful imitation	0.486*	0.529*	0.058	0.087	0.419	−0.084	0.532*
Manual imitation	0.518*	0.439	−0.089	0.074	0.328	0.132	0.246
Oral-facial imitation	0.420	0.359	−0.078	−0.099	0.226	0.043	0.336
Overall immediate imitation	0.475*	0.489*	−0.010	0.011	0.349	0.053	0.382
Deferred imitation	0.172	0.114	0.290	−0.185	−0.140	0.234	−0.038
Overall imitation	0.494*	0.493*	0.031	0	0.331	0.065	0.361
Developmental Delay							
Meaningful imitation	0.338	0.436	0.651**	0.519*	0.513*	−0.168	−0.188
Non-meaningful imitation	0.174	0.314	0.303	0.107	0.241	−0.182	−0.293
Manual imitation	0.226	0.288	0.397	0.301	0.298	−0.036	0.183
Oral-facial imitation	0.102	0.252	0.273	0.292	0.274	0.164	0.398
Overall immediate imitation	0.277	0.388	0.486*	0.379	0.398	−0.021	0.071
Deferred imitation	0.205	0.329	0.212	0.216	0.275	−0.122	−0.090
Overall imitation	0.213	0.324	0.385	0.260	0.298	−0.001	0.055

FM, Fine motor functioning; NVMA, non-verbal mental age; EL, Expressive language; VMA, verbal mental age, MA, mental age; IJA, Initiating joint attention.
*$P < 0.05$, **$P < 0.01$.

in the non-meaningful condition, as was suggested by Hobson & Lee (1999), tasks involving the measurement of imitation style were added but we modified and simplified their measurements to suit preschoolers with ASDs. The reason that the imitative style task was not used in study 1 was due to concern that it might be too difficult for younger children who have limited fine motor ability. The hypothesis of study 2 was twofold. First, if the deficit in non-meaningful imitation of actions on objects is crucial to children with ASD, they will still have a deficit in non-meaningful imitation of actions on objects 18 months later. Second, based on Hobson's proposal, we predicted that children of preschool age with ASDs would exhibit impairment in style of action on object imitation.

Method

Participants

Only children from the ASDs and DD groups from study 1 were invited to participate in study 2. Eleven children with ASDs (9 with autism and 2 PDDNOS) and 11 children with DD finished all tasks from study 2 (see Figure 1).

To match the two groups on developmental ability, the MSEL (Mullen 1995) was again administered. One DD child performed at ceiling on the fine motor subscale. In order to obtain an appropriate measure of his fine motor skills, we replaced the fine motor subscale by the following formula: fine motor equivalent (study 1)/CA (study 1) × CA (study 2). Independent t-tests demonstrated that the ASDs group was matched with the DD group in terms of CA and developmental abilities. The parents of ASDs and DD groups were similar in terms of socioeconomic status [t (20) = 1.63, $P = 0.118$] (Huang 1998). (see Table 6).

Measures

A total of 6 tasks were carried out in study 2. Four tasks were executed in a 2 (meaningful versus non-meaningful) × 2 (single versus 2-step) within-subject design. The remaining two tasks were the harsh and gentle styles of action on object imitation. The harsh style was when the examiner demonstrated an action with a quick and rough manner. The gentle style, in contrast to the harsh style, was when the examiner demonstrated an action in a slow and soft manner. See Table 7 for a description of the 2-step sequence and style imitation actions. The procedures in this study were the same as those used in study 1.

To rate both single and sequence object imitation, the response accuracy was scored in the same way as in

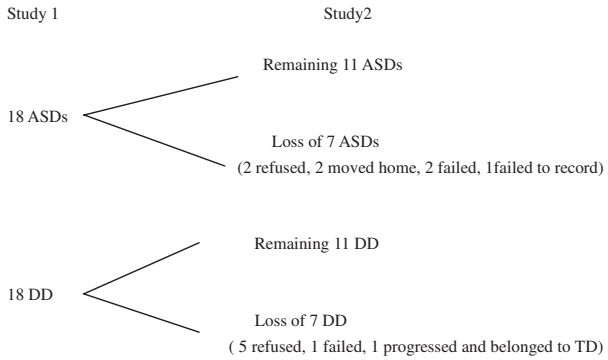

Figure 1 The distribution of remaining and loss participants.

Table 6 Participant characteristics of study 2

	ASDs (*n* = 11)	*DD* (*n* = 11)
Chronological Age		
Mean[1] (SD)	58.18 (7.72)	57.91 (6.24)
Range	44–70	46–70
Non-verbal mental age		
Mean (SD)	48.41 (11.77)	48.36 (11.14)
Range	28.5–65.5	38–73
Fine Motor Equivalent		
Mean (SD)	47.55 (12.27)	49.91 (11.26)
Range	28–65	40–77
Verbal mental age		
Mean (SD)	37.68 (7.68)	37.91 (9.52)
Range	25.5–49	28–56
Overall mental age		
Mean (SD)	43.05 (9.21)	43.14 (10.18)
Range	27–57.25	33–64.5
Socioeconomic Status		
Mean (SD)	64.27 (20.00)	52.82(11.86)
Range	35–98	35–70

[1]months
ASDs, autism spectrum disorders; DD, developmental delay; SD, standard deviation.

study 1. To rate the style of action on object imitation, emerging style response quality was scored using a 3-point scale: a clear and intact style response earned 2 points, an emerging but not clear and intact style response earned 1 point, and a failure in style response earned 0 points. To determine the level of inter-rater reliability, two coders independently rated ten (38%) videotapes. The Cohen's kappa was 0.72 ($P = 0.000$) across the six imitation tasks, indicating good agreement. The percent agreement was 88% for object imitation and 90% for style imitation.

Table 7 Additional items on the imitation tasks of study 2

Type	*Item*
Sequence imitation action:	
Meaningful	Turn bowl right-side up and stir spoon
	(Turn bowl right-side up and pretend spooning something out)
	Turn plate upside-down and wipe the plate using dishcloth
	(Turn plate upside-down and tap it using dishcloth)
	Turn toy table right-side up and put toy chair on table top
	(Turn toy table right-side up and put toy chair upside-down on table top)
Non-meaningful	Turn toy car upside-down and knock the car using stick
	(Turn toy car upside-down and push the car using stick)
	Turn L-shaped box right-side up and place the stick on top of the box
	(Turn L-shaped box right-side up and place the stick on at the coner of the L shape)
	Cover a block using cup and turn it around
	(Turn cup up-side down and put a block on the top of cup)
Style imitation action:	
Harsh and gentle	Knock the table using a soft ball
	Push toy truck across table
	Walk zebra across table

(), Alternative target action.

Results

Independent *t*-tests were used to investigate whether any differences were exhibited between groups. The results revealed that children with ASDs were significantly impaired compared to children with DD in single non-meaningful imitation [t (20) = 2.577, $P = 0.018$], harsh style imitation [t (20) = 2.356, $P = 0.029$] and gentle style imitation [t (20) = 2.173, $P = 0.042$], but not in single meaningful imitation [t (20) = 1.870, $P = 0.076$], 2-step sequence meaningful imitation [t (20) = 0.660, $P = 0.517$] and 2-step sequence non-meaningful imitation [t (20) = 1.327, $P = 0.20$] (see Table 8). Due to

the small sample size, we also used a non-parametric analysis. The results were similar to those using a parametric analysis.

General Discussion

Two experiments were performed to investigate imitative abilities in children with ASDs. Study 1 compared the immediate and deferred imitation abilities in children with ASDs to children with DD and children with TD. This study also investigated the relationship between imitation, JA, and play in children with ASDs and with DD. In study 2, based on the findings of study 1, children in the ASDs and DD groups were followed up after 18 months and their action on object imitation abilities were examined, including style of imitation.

The results from study 1 revealed that children with ASDs exhibited significantly poorer performance to the two control groups only on the imitation of non-meaningful manipulations of objects. Children in both the ASDs and DD groups performed significantly worse than TD children on deferred imitation. Study 2 found that, after 18 months, children with ASDs still performed more poorly than children with DD on the imitation of single non-meaningful manipulations of objects. The results suggested that although children with ASDs show some improvement from time 1 to time 2, they continue to show impairment in imitating unconventional manipulations of objects compared to children with DD. Finally, as we predicted, study 2 also found that children with ASDs exhibited deficiencies in style of action on object imitation.

Consistent with a previous study (Stone *et al.* 1997), children with ASDs exhibited significantly impaired performance compared to both the DD and TD groups in manipulating objects using non-meaningful actions. Neither manual nor oral-facial imitation differed between the three groups in study 1, a result consistent with the findings of Rogers *et al.* (2003) regarding manual imitation but not regarding oral-facial imitation. Two children with PDDNOS were removed from the ASDs group; however, the results still showed no difference between groups on either task. It implies that the negative findings did not result from the inclusion of children with PDDNOS. Exploring the data further, we found that eight children with ASDs scored more than five points on the manual imitation task. Moreover, nine children with ASDs scored more than five points on the oral-facial imitation task. The high proportion of children with ASDs (44.44%) achieving excellent performance represents a possible reason for the lack of a significant difference between groups.

As suggested by Rogers *et al.* (2003), this study divided the ASDs group into strong and weak imitators. Strong imitators ($n = 8$) were defined as children with overall imitation scores exceeding 19 in study 1. Strong imitators displayed significantly better performance than weak imitators in FM, NVMA, MA, and IJA. The strong imitators had better social-cognitive abilities indicating that it is important to consider individual differences in developmental abilities to better understand the nature of imitation in children with ASDs.

Children with ASDs also had significantly poorer performance than children with DD in non-meaningful manipulations of objects, and both harsh and gentle style imitation, at study 2. However, significant variation existed in the performance of both styles of imitation. In fact, four children with ASDs performed excellently on this task. The reasons for this excellent performance are unclear; however, to address the question, Hobson & Meyer (2006) proposed three style types, including style-as-goal, style-for-goal, and goal-with-style. Based on Hobson and Meyer's proposal, study 2 is a style-for-goal design because the child gets full points only if both the style of the action and the action itself are imitated correctly. Contrary to what Hobson and Meyer suggested, our study found that some children with ASDs succeed in the style-for-goal task, while others displayed significant impairment compared to children with DD. To understand the nature of failure

Table 8 Imitation performances of both groups in study 2

	ASDs ($n = 11$)	*DD* ($n = 11$)
Single meaningful imitation		
Mean (SD)	3.45 (1.57)	4.54 (1.13)
Single non-meaningful imitation		
Mean (SD)	3.55[1] (1.86)	5.18 (0.98)
Sequence meaningful imitation		
Mean (SD)	4.18 (1.66)	4.64 (1.57)
Sequence non-meaningful imitation		
Mean (SD)	3.45 (2.21)	4.64 (1.96)
Harsh style imitation		
Mean (SD)	2.82[1] (2.48)	4.82 (1.33)
Gentle style imitation		
Mean (SD)	2.00[1] (3.91)	3.91 (2.17)

[1]ASDs < DD, $P < 0.05$.

ASDs, autism spectrum disorders; DD, Developmental Delay, SD, standard deviation.

or success in imitating different styles of action, future studies should recruit more participants and follow them over time so that individual differences among children with ASDs can be explored.

No significant impairment existed between the ASDs group and DD group on deferred imitation in study 1. Two of the three deferred imitative tasks were actions with a sensory feedback effect. The literature has demonstrated that the sensory feedback effect facilitates imitation performance (Roeyers *et al.* 1998; Ingersoll *et al.* 2003). The results from this study support the idea that children with ASDs have similar abilities to controls on deferred imitative tasks with a sensory feedback effect. However, caution needs to be taken in concluding that children with ASDs have similar abilities to controls in deferred imitation in general.

It remains unclear why children with ASDs displayed intact imitation of the 2-step non-meaningful acts in study 2. The first step of the non-meaningful acts was unfamiliar and non-conventional in the sense that it was rarely generated in a spontaneous manner during the baseline phase. However, the arbitrary nature of non-meaningful acts does not mean that they are non-intentional. If they are non-intentional, sequential causal inference would not serve as an effective strategy for replicating the observed acts. In fact, the results suggest that imitation of the second step can be facilitated by imitation of the first step. The two acts involved in the task appear causally related to each other. This may explain the relative performance by children in the ASDs. Further studies should address sequential causal inference inherent in multi-step imitation tasks.

Based on the current findings, this study argues that the non-meaningful imitation of actions on objects is a good candidate for explaining the nature of the imitative deficit in young children with ASDs. Two competing theories exist to explain the basis of non-meaningful actions on object imitation: a deficit in executive function (Ozonoff 1997; Ozonoff & Jensen 1999) and a deficit in intersubjective understanding (Hobson & Lee 1999; Tomasello *et al.* 2005). Executive function behaviours include planning, impulse control, memory, flexibility of thought and action etc. Some researchers have suggested that individuals with autism mainly suffer from inflexibility and impaired planning (Ozonoff 1997; Ozonoff & Jensen 1999). Active talking responses of a pair of ASD children in our study support their suggestion. For example, when the examiner demonstrated a non-meaningful action on an object, a high-functioning child with autism said 'you can't do that.' Later, when the object was given to the child, the child performed a meaningful action and said 'you must do this.' Another high-functioning child with autism repeatedly said 'eat' when the examiner used a bowl, spoon, etc. These behaviours suggest a deficiency in flexibility of thought in autism. However, this does not explain the difficulty experienced by children with autism in imitating the style of actions applied to objects. Although an executive function deficit may be a good candidate to explain difficulties in imitating style of actions, a deficit in understanding intersubjectivity is more suitable. Intersubjectivity refers to the sharing of internal subjective experience, including intention, belief, emotion and so on, with another.

Hobson & Lee (1999) addressed the idea that 'identification' is the core deficit in autism and suggested that individuals with autism do not properly connect perceptions and responses to other psychologically expressive aspects of behaviour (e.g. the expression of emotions). Recently, Tomasello *et al.* (2005) proposed that to engage in human social and collaborative activities, understanding intention only is insufficient; something additional is required, namely shared intentionality. Both of above theoretical perspectives argued that children with ASD would have abnormalities in imitation, particularly in imitating actions related to social engagement. Our study suggested that some object imitation skills, particular non-meaningful imitation and style of imitation, is related to the above domain. Imitating unconventional actions (or action styles) requires not only the ability to infer intentional instrumental purposes but also the ability to share interesting (novel in some sense) results with the examiner. As Tomasello *et al.* suggested children with ASDs can understand intentions but not shared intentionality, and thus they performed poorly in this kind of imitation task. For example, after observing the examiner demonstrate gentle and harsh actions, a child with ASD said, 'you did it so gently' and 'you did it so harshly' but failed to imitate the style of action. The words he said meant that he understood the examiner's intentional action, but he had no interest in copying the qualitative action. In fact, Hamilton *et al.* (2007) proposed that children with ASDs showed intact ability to understand the goal of the object-directed imitation task. However, as was previously mentioned, although group comparison showed that children with ASDs were impaired on the style of imitation task, future studies are needed to explain the variability in performance.

This study has the following limitations: (i) the sample size in study 1 was not large enough, resulting in a small sample size in study 2. We were, therefore, unable

to discuss individual differences within the ASDs group for better understanding of imitative impairments; (ii) most children with ASDs attended different intervention programs outside of the research project and parents were unable to report clearly about the types and hours of intervention. Due to the lack of intervention information, the influence of intervention on the performance of children in the ASDs and DD groups was uncertain; (iii) the ADOS and ADI-R were not translated into the Mandarin language at the time of this study, and it was not possible to assess whether changes in ASD symptomatology or severity over time affected performance on imitation tasks; (iv) this study did not distinguish familiar/conventional/meaningful actions from unfamiliar/non-conventional/non-meaningful actions in either the manual or oral-facial imitative tasks. Therefore, the tasks as designed may have been unable to detect any difference that may have existed between groups. That is why, when the results between the three groups were not significant, this study conservatively concluded that children in the ASDs group performed similarly to those in the DD and TD groups on these two imitation tasks; (v) study 2 did not include children with typical development, reducing the ability of the results to indicate that deficits in the style of imitation task were specific to children with ASDs and (vi) the ESCS and imitation tasks were administered by the first author so we are unable to rule out potential examiner bias in the three groups. Further studies that take account of these limitations in design are required in the exploration of the nature of imitative impairment in children with ASDs.

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