THE JOURNAL OF
CHILD PSYCHOLOGY AND PSYCHIATRY

ACAMH

Journal of Child Psychology and Psychiatry 49:4 (2008), pp 449–457 doi:10.1111/j.1469-7610.2007.01866.x

Deferred and immediate imitation in regressive and early onset autism

Sally J. Rogers, Gregory S. Young, Ian Cook, Angelo Giolzetti, and Sally Ozonoff

The M.I.N.D. Institute, University California Davis, USA

Deferred imitation has long held a privileged position in early cognitive development, considered an early marker of representational thought with links to language development and symbolic processes. Children with autism have difficulties with several abilities generally thought to be related to deferred imitation: immediate imitation, language, and symbolic play. However, few studies have examined deferred imitation in early autism. The present study examined both deferred, spontaneous imitation and immediate, elicited imitation on a set of carefully matched tasks in 36 young children with autism: 16 with early onset autism, 20 with regressive autism and two contrast groups, younger typically developing children ($n = 20$) and age matched children with significant developmental delays ($n = 21$). Analyses of co-variance controlling for differences in verbal mental age revealed significant main effects for task, but no main effect of group and no interaction of task by group. Deferred imitation scores were lower than immediate imitation scores for all groups. Imitation performance was related to overall intellectual functioning for all groups, and there were moderate and significant relations between imitation in the immediate elicited condition and in the spontaneous deferred condition for all groups. Finally, there were no differences between onset subgroups in imitation scores, suggesting that the two share a similar phenotype involving both types of imitation. **Keywords:** Autistic disorder, development, developmental delay, mental retardation, pervasive developmental disorder, preschool children, imitation.

Difficulty with immediate imitation of other people's movements in autism has been well documented in a variety of studies across the past 30 years (see Rogers & Williams, 2006 for the most recent review of this literature). Autism-specific deficits in imitation have been repeatedly reported in studies comparing children with autism to those with other developmental disorders as early as age 2 (Charman et al., 1997; Rogers, Hepburn, Stackhouse, & Wehner, 2003; Stone, Ousley, & Littleford, 1997), and continue into adulthood (Rogers, Bennetto, McEvoy, & Pennington, 1996). Studies have tended to use three kinds of tasks: actions on objects, manual and postural movements, and oral-facial movements. Persons with autism typically demonstrate impaired performance compared to controls on all three types of tasks, although imitation of simple means–end actions on objects is generally much less affected (for some examples see DeMyer et al., 1972; Stone et al., 1997; Rogers et al., 1996, 2003; Charman et al., 1997; and Ohta, 1987).

Interestingly, though immediate imitation has been examined in well over 50 studies of autism at this point, there are very few studies of deferred imitation (imitation after a delay period) in autism. Deferred imitation holds a privileged position in theories of cognitive development. Piaget attributed great importance to deferred imitation in the development of representational thought. He stated that internalized, or mental, images were a product of imitation, evidenced by deferred imitation (Piaget, 1962). Piaget stated that, in deferred imitation, the child demonstrates a capacity for, 'imitating internally a series of models in the form of images… Imitation thus begins to reach the level of representation' (Piaget, 1962, p. 69). These images, engendered by deferred imitation, function as symbols, as demonstrated by toddlers' abilities to use familiar movements to represent an absent object. Piaget suggested that the co-occurrence of speech, deferred imitation, and symbolic play in the 18–24-month period were evidence of the capacity for generalized representational thought.

In the past two decades, evidence of the capacity for deferred imitation in much younger infants has accumulated. Meltzoff (1988a, 1988b) demonstrated deferred imitation of several simple novel actions on objects after a one-week delay in 14-month-olds, and in 9-month-olds after a 24-hour delay. Several groups have demonstrated deferred imitation of actions on objects after delays ranging from 10 minutes to 24 hours in 6-month-olds (Collie & Hayne, 1999; Learmonth, Lamberth, & Rovee-Collier, 2004). Meltzoff and Moore (1992) demonstrated deferred imitation of a specific behavior – tongue protrusion – after 24 hours in 6-week-old infants. Findings from these studies, taken together, indicate that representational capacity is present much earlier in infancy than Piaget suggested. While there has been some debate about the type of memory that underlies these performances, most agree that these paradigms involving entirely novel acts, modeled once and

Conflict of interest statement: No conflicts declared.

Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA

without allowing any practice, involve recall, or declarative memory (Mandler, 1990).

The studies above documented that deferred imitation is present before language or symbolic play. Furthermore, Nielsen and Dissanayake (2004) supported a prerequisite role for deferred imitation in infant acquisition of other representational capacities. In a large longitudinal study of 100 infants from 12–24 months, they demonstrated that deferred imitation preceded development of pretend play, mirror self-recognition, and synchronic imitation in 60% of the infants, and deferred imitation was the only one of the four abilities to demonstrate a significant prerequisite relationship with the others. Similarly, Toth, Munson, Meltzoff, and Dawson (2006) demonstrated that, while immediate imitation skills predicted concurrent language abilities, deferred imitation (as well as symbolic play) predicted growth in language ability across a two-year time span in a large group of preschoolers with autism.

Deferred imitation in autism

While immediate imitation has been well studied in autism, deferred imitation has been examined in only two papers. McDonough, Stahmer, Schreibman, and Thompson (1997) provided the first examination of deferred imitation in autism. The study involved baseline, immediate imitation and deferred imitation of familiar and novel, meaningful and nonmeaningful actions on objects, both single and sequenced, in 6 children with autism, mean age 4.5 years, compared to 12 typically developing children, 6 matched for language and 6 matched for nonverbal level. They found autism deficits in baseline conditions, but no autism deficits in any imitation condition. Given the small group sizes and initial findings, they highlighted the need for additional studies of deferred imitation.

In contrast, Dawson, Meltzoff, Osterling, and Rinaldi (1998) found autism-specific deficits on both immediate and deferred imitation tasks in a group of 20 preschoolers with autism compared to two contrast groups, one with delayed development and one with typical development. The authors examined relationships involving immediate and deferred imitation and core symptoms of autism. They also examined relations between imitation and performance on two neuropsychological tasks – delayed non-match to sample, thought to be mediated by the medial temporal lobe system, and the delayed response task, mediated by the dorsolateral prefrontal system. For the group with autism, immediate imitation performance was significantly and moderately correlated with performance on both the prefrontal task and the medial temporal task, while deferred imitation was very strongly and significantly correlated with performance only on the medial temporal task, as were most of the other core autism symptoms. Relationships between immediate and deferred were moderate and significant ($r = .53$, $p < .001$). Furthermore, both were significantly related to language performance and progress (Toth, Munson, Meltzoff, & Dawson, 2006). Given the contradictory findings of these two papers concerning both deferred and immediate imitation performance, the primary goal of the present study was to examine performance of young children with autism on deferred imitation tasks and the relation between immediate and deferred imitation performance.

Neuropsychological profiles of young children with regressive versus early onset autism

There is considerable heterogeneity within autism, and increasing questions concerning biological subtypes within autism. Currently, there is growing emphasis on research designs that reduce heterogeneity as much as possible within autism samples in order to help map behavioral symptoms onto possible biological sources (Newschaffer et al., 2007). Differing onset patterns in autism have recently begun to be considered as a possible indication of different biological subtypes (Richler et al., 2006). Some studies have demonstrated differing neuropsychological profiles in early autism related to differing onset patterns (Richler et al., 2006; Rogers & DiLalla, 1990), though there are also nonreplications (Werner, Dawson, Munson, & Osterling, 2005). However, such studies have thus far focused on general symptoms: IQ, language, and severity of autism, with the surprising finding that, if there were any group differences, they tended to fall in the direction of better performance in the early onset than the regressive subgroups. This is a counterintuitive finding in that developmentalists would expect that more intact social and communicative development in the first year of life should predict less severe impairment, rather than more severe, and does not fit a developmental cascade model of autism. However, studies of the neuropsychological effects of onset differences on core developmental skills like imitation and joint attention have not yet been carried out. For these reasons, a second goal of the current study was to compare deferred and immediate imitation performance in both early onset and late onset autism.

Hypotheses

There were two main hypotheses to be tested. First, we predicted that children with autism would demonstrate greater impairment in deferred imitation compared to immediate imitation performance than would matched controls. Thus, we predicted an interaction of group by task. This prediction was based on the findings by Dawson and colleagues (1998) concerning the pattern of autism-specific difficulties on their medial temporal battery as well as their findings concerning deferred imitation performance. Second, given previous findings of more severe impairments in regressive autism than early onset autism, we predicted greater impairment in both immediate and deferred imitation in the children with regressive autism compared to those with early onset autism. A secondary hypothesis predicted a main effect of task, given the findings from various developmental studies that deferred imitation develops after immediate imitation.

Method

Procedures

The study was conducted under the approval of the Institutional Research Review Board at the University of California, Davis. The study was explained to the parents orally and in writing, all their questions answered, and consent obtained before gathering measures. The measures for this study were given as part of a larger battery; other measures will be reported in subsequent papers.

Participants

Seventy-seven participants were included in this study and comprised four groups: early onset autistic disorder (EO; $n = 16$), regressive onset autistic disorder (R; $n = 20$), developmental delay of mixed etiology (DD; $n = 21$), and typically-developing children ($n = 20$). All participants were recruited from the M.I.N.D. Institute Research Participant Recruitment Core, and from various health and early education agencies and parent support groups. The groups did not differ with respect to the percentage of ethnic minority and Caucasian participants included ($X^2 = 2.54$, df = 3, $p = .47$), with approximately 33% of the sample (26 out 77) composed of participants from an ethnic minority group. In addition, there were no significant group differences in SES based on Hollingshead (1975) scores (F (3, 54) = 1.17, $p = .33$). There were, however, significant differences in the gender composition of the groups ($X^2 = 11.20$, df = 3, $p < .05$). Follow-up examination of the standardized Pearson residuals suggested that this group by gender interaction was due primarily to a greater proportion of females in the typical group than comparison groups (9 out of 20, standardized Pearson residual = 2.0). However, there were no differences based on gender in either deferred imitation ($t = .07$, df = 76, $p = .95$) or immediate imitation ($t = 1.22$, df = 76, $p = .23$). As such, gender was not included as a design factor in any subsequent analyses.

The children with autistic disorder (both early onset and regressive onset) ranged in age from 26 months to 59 months. They were free from any other medical condition and had no visual or hearing impairment. Multiple diagnostic criteria were used to confirm the presence of autism. Each child had been previously diagnosed with autistic disorder or pervasive developmental disorder not otherwise specified (PDDNOS; DSM-IV) by developmental disability specialists independent of the research group, received a current clinical diagnosis of autistic disorder according to DSM-IV criteria from a clinician in the research group, and met full criteria for autistic disorder on both the (3) ADI-R and (4) ADOS-G.

Participants were subdivided into two onset groups based on the two ADI-R questions, numbers 11 and 25, regarding onset status. The early onset group was defined by a score of 0 (parents' report of no skill losses) to two items on the ADI-R: question 11 (loss of at least 5 words), and question 25 (probable or definite loss of social abilities, such as social interest, engagement with others, etc.). The regression group was similarly defined by an ADI-R score of 1 on question 11 (loss of words) and a score greater than 1 on question 25 (definite loss of social abilities). Given that regression occurs less frequently than early onset in most autism samples, we specifically recruited children with regression in order to have relatively equal numbers in the onset groups. No reliability scores were calculated for the regression grouping since this was generated by the computer by ADI-R scores, and not by human calculations. The team had established appropriate reliability on the ADI-R, as reported in the methods section. Test–retest reliability has previously been established on all items of the ADI-R (Lord, Rutter, & Le Couteur, 1994) and long-term reliability of parental reports of skill loss was recently reported as being higher than 80% (Luyster et al., 2005)

The group of children with developmental delays (DD) was recruited to provide both a chronological and a developmental age match for the groups with autism. Children with DD ranged in age from 29 months to 59 months. All had normal vision and normal hearing or vision corrected to within the normal range, unimpaired hand use, and were mobile. None were considered by any clinician on our team to have autism and none met criteria for autistic disorder on the ADOS. The group was heterogeneous, and included 10 children diagnosed with language delay, 3 with Down syndrome, 5 with global developmental delay, 2 with sensory integration disorder, and 1 with an unknown genetic syndrome.

The typically-developing (TD) group was recruited to provide a developmental age comparison for the children with autism. The TD group ranged in age from 15 to 42 months. All had normal hearing and vision and did not present with any significant medical or developmental concerns. None of these children met criteria for an autism spectrum disorder on any of the diagnostic instruments used in this study.

Measures

Symptoms of autism. Autism Diagnostic Interview – Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994). The ADI-R is a structured, standardized parent interview developed to assess the presence and severity of symptoms of autism in early childhood across all three main symptom areas involved in autism: social relatedness, communication, and repetitive, restrictive behaviors. The ADI-R has been carefully psychometrically validated across a wide range of ages and severity levels in autism. Dr Lord and her team trained some of the research team members to reliability on the ADI-R; they then trained other raters in her lab to reliability of 85% or better item agreement on three consecutive administrations using the full range of scores (0–3) rather than the truncated scoring usually used (0–2). Reliability was maintained at 85% for 20% of participants across the period of data gathering.

Autism Diagnostic Observation Schedule – WPS Edition (ADOS-G; Lord, Rutter, DiLavore, & Risi, 1999). The ADOS-G is a semi-structured standardized interview using developmentally appropriate social and toy-based interactions in a 30–45-minute interview to elicit symptoms of autism in four areas: social interaction, communication, play, and repetitive behaviors. The ADOS-G consists of four different modules, each directed at a particular level of language ability. In the present study, all participants received Module 1, for preverbal children or those just beginning to speak. One or more lab personnel were trained to reliability on the ADOS-G with Dr Lord's lab. That person then trained others in the present lab to reliability of 85% or better item agreement on three consecutive administrations using the full range of scores (0–3) rather than the truncated scores (0–2) typically used. Reliability was maintained at 85% by double-scoring 20% of protocols across the period of data gathering.

Developmental. Mullen Scales of Early Learning (MSEL; Mullen, 1989). The MSEL is a standardized developmental test for children ages 3 months to 60 months consisting of five subscales: gross motor, fine motor, visual reception, expressive language, and receptive language. The MSEL demonstrates strong concurrent validity with other well-known developmental tests of motor, language, and cognitive development. The MSEL was administered to all participants according to standard instructions by raters with advanced degrees, trained in assessing young children with autism and other developmental disorders. Reinforcers for all participants in all groups were used at times to reward cooperation and attention. Mental age scores in verbal (mean of the receptive and expressive language age equivalents), nonverbal (mean of fine motor and visual reception age equivalents), and overall intellectual functioning (mean of all 4 of these subscale age equivalents) were used as matching criteria.

Experimental tasks

Six simple deferred, spontaneous imitation items and six matched immediate, elicited imitation items were designed and administered as part of a larger study of imitation in autism. The tasks involved simple means–end actions on objects, the kinds of tasks that children with autism have the least difficulty imitating. The deferred imitation tasks were modeled from Meltzoff (1988a, 1988b). Items were matched a priori on motor complexity and object properties. Items from the two conditions were given in counterbalanced blocked order. Conditions were not mixed. Table 1 lists each of the deferred imitation items and the respective matched immediate imitation items.

Administration

In the immediate imitation condition, target actions were modeled by first capturing the child's attention, saying '[name], do this,' and then performing 3 rapid repetitions of the target act before handing the object to the child. If the child did not imitate the act following the first model, then a second model of 3 rapid repetitions of the target action was provided. If the child failed to perform the target action after 3 models (each consisting of 3 bursts of actions), the experimenter continued with the next item.

Each deferred imitation task was first presented to the child to manipulate in a baseline condition. If the child produced the specified action in the baseline condition, then an alternate target act of similar complexity was demonstrated. For some of the items that had easily discovered functions (dumbbell, egg), a non-functioning version of the object was used in the baseline condition only (e.g., an empty egg was used in place of an egg with beads inside). All six items were given consecutively for 60 seconds each during the baseline condition, with no prompting or reinforcement from the experimenter. After all 6 items had been presented to the child during the baseline condition, the experimenter then gained the child's visual attention, saying, 'Watch this,' and modeled the target action for each of the same 6 items, placing the object out of sight from the child after each model. After the last item was presented, the experimenter went on to a different set of tasks. After approximately 60 minutes, the deferred imitation objects were then presented to the child one at a time, in the same order as the demonstration. No instructions or models were given. Thus, the deferred

Table 1 Immediate and deferred imitation tasks

	Deferred imitation	Immediate imitation
1	Hamster: activate by pinching foot	Squeak Toy: activate with elbow
	Hamster (alternative): shake in air	Cloth Loop: shake in air
2	Dumbbell: pull apart, push together	Duplo Blocks: pull apart, knock together
	Dumbbell (alternative): rotate in air	Potato Masher: rotate in air
3	Egg: shake to make noise	Maraca: shake to make noise
4	Bottle & Stick: bang side with stick	Box: bang box with stick
	Bottle & Stick (alternative): Invert and bang with stick	Car: invert and pat with hand
5	Sandals: bang on table	Sticks: bang on table (ulnar grip)
6	Head & Light (using head)	Marker: draw on paper with marker between teeth
	Head & Light (using hand)	Marker: draw on paper

imitation task is a spontaneous imitation task, and the actions involved very simple, functional acts on relatively novel objects – the kinds of imitation tasks in which children with autism typically show the least impaired performance (DeMyer et al., 1972; Hobson & Lee, 1999).

Scoring

Each item was scored pass or fail, based on whether the child clearly demonstrated the target act or a close approximation of the target act on the object within 20 seconds. A passing score for each item was behaviorally defined for raters. Scoring was completed from video by raters blind to hypotheses, condition, adult model, and diagnoses. Two imitation scores were calculated from each of these scales, an immediate imitation proportion score and a deferred imitation proportion score, each consisting of the number of items passed divided by the total number of items administered (all participants had between 5 and 6 of the items administered in each scale). Two coders independently coded 20% of the data. Inter-rater agreement was calculated using both percent agreements, ranging from .88 to 1.0 and the kappa statistic, which ranged from .70 to 1.0.

Results

Preliminary examination of data

Scores for deferred imitation were normally distributed (using the Shapiro–Wilk statistic) for each of the groups; scores for immediate imitation, however, were significantly negatively skewed for all the groups, indicating the presence of ceiling effects. A further examination of the histograms for immediate imitation scores revealed that 13 of the 21 DD participants and 10 of the 20 typically-developing participants passed all items in the immediate imitation condition. Importantly, however, the ranges of scores did not differ between groups and a test of the multivariate covariance matrices using Box's M statistic was not significant (Box's M = 6.80, F (9, 55,663) = .72, $p = .69$). As such, we conducted parametric tests despite the presence of ceiling effects in the immediate imitation condition for the comparison groups. Indeed, results of nonparametric analyses of the same data (e.g., Kruskal–Wallis Test, Mann–Whitney U Test, and Wilcoxon Signed Ranks Test) were entirely commensurate with the results of parametric tests reported below.

An examination of the relationship between immediate and deferred imitation revealed that scores for both scales were significantly correlated across all groups ($r = .47$, $p < .001$) and this relationship was similar (though only marginally significant) for each group individually (correlations ranging from .21 (95% CI = −.25 to .64) to .68 (95% CI = .36 to 1.00)). A multiple regression analysis that examined main effects of group, immediate imitation, and the interaction between group and immediate imitation as predictors of deferred imitation revealed no interaction effect, suggesting that the relationship between immediate and deferred imitation did not differ as a function of group, despite the seemingly different zero-order correlations (F (3, 69) = .59, $p = .62$). The correlations among all the variables are provided in Table 2; since the relationship among these did not differ significantly by group, correlations are given for the entire sample.

Mean chronological ages and developmental ages for the sample are provided in Table 3. As can be seen in that table, even though the design was intended to minimize group differences, nevertheless

Table 2 Correlations between all variables for entire sample ($n = 77$)

	Immediate imitation	Verbal MA	Nonverbal MA	Overall MA	Chronological age
Deferred imitation	.47***	.42***	.35**	.40***	.15
Immediate Imitation		.45***	.35***	.41***	.02
Verbal MA			.88***	.97***	.39***
Nonverbal MA				.96***	.59***
Overall MA					.50***

**p < .01; ***p < .001.

Table 3 Description of the four subject groups

	Autism (EO) $n = 16$	Regression $n = 20$	DD $n = 21$	Typical $n = 20$	F
Chronological age	35.80[a] (5.93)	45.98[b] (8.44)	43.15[b] (9.46)	23.23[c] (7.90)	31.44***
Verbal MA	17.47[a] (10.61)	19.85[a,b] (8.07)	27.76[c] (11.04)	25.03[b,c] (9.89)	4.20**
Nonverbal MA	23.25[a] (8.92)	27.70[a,b] (6.37)	31.67[b] (10.68)	25.00[a] (9.12)	3.21*
Overall MA	20.36[a] (9.43)	23.78[a] (6.94)	29.71[b] (10.63)	25.01[a,b] (9.38)	3.31*

***p < .001; **p < .01; *p < .05.
[a,b,c]Means that share a subscript are not significantly different.

there were significant overall group differences on chronological age, as well as nonverbal, verbal and overall mental age. Follow-up comparisons revealed that the typically-developing group was comparable to both groups with autism on nonverbal mental age scores, with *p*-values above .34, but both the DD group and the typically-developing groups had higher verbal mental age scores than both onset subgroups of children with autism (*p*-values from .003 to .10).

The relationships between imitation scores and cognitive functioning scores were examined using correlational analysis. Both verbal and nonverbal mental age scores were significantly related to both deferred and immediate imitation scores, with coefficient values ranging from $r = .33$ (95% CI = .11 to .54) to $r = .45$ (95% CI = .25 to .66). Given these relationships between imitation and cognitive functioning in addition to the significant group differences for verbal mental age in particular, as reported above, we decided to use verbal mental age as a covariate in the primary analyses of group differences in imitation reported below.

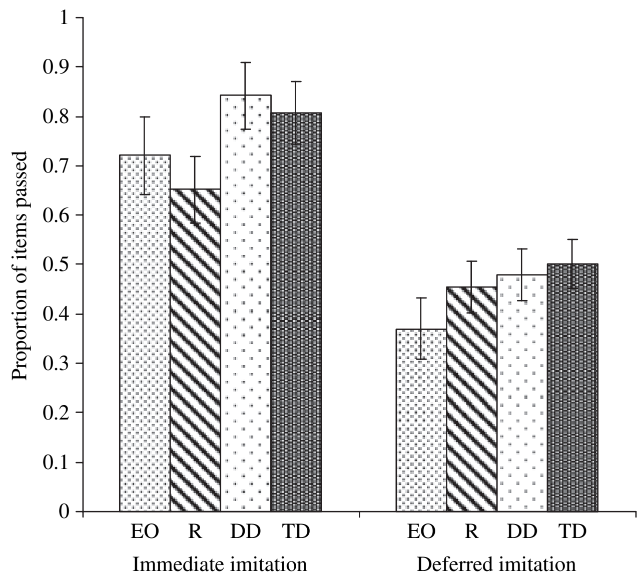

Figure 1 Proportion of items passed on immediate and deferred imitation tasks for children with early-onset autism (EO), regressive autism (R), developmental delays (DD), and typical development (TD), controlling for verbal mental age

Analysis of group differences

Differences in group means on the two types of tasks were examined using a 2-within by 4-between mixed design ANOVA procedure. The imitation condition – immediate or deferred – comprised the 2-level within-participants factor; and diagnostic group – typical, DD, autism early onset, and autism regression – comprised the 4-level between-participants factor.

Results revealed significant main-effects for imitation type (F (1,73) = 70.48, $p < .001$, $\eta^2 = .49$) and for group (F (3,73) = 4.08, $p < .01$, $\eta^2 = .14$). There was no significant interaction of task by group (F (3,73) = 1.10, $p = .36$, $\eta^2 = .04$).

Follow-up tests of the group main effect revealed that both the early onset autism group and regressive autism group passed significantly fewer imitation items overall than the DD group (t (36) = 2.51, $p < .05$ and t (40) = 2.40, $p < .05$ respectively) and the Typical group (t (35) = 2.57, $p < .05$ and t (39) = 2.42, $p < .05$ respectively). There was no difference between either onset group and no difference between the DD group and the typically developing group. Inspection of the estimated means for imitation across groups revealed that the main effect for imitation was due to a significantly lower proportion of deferred imitation items passed by all participants (M = .46, SE = .03) than immediate imitation items (M = .73, SE = .03).

This analyses was then repeated using a 2-within by 4-between mixed design ANCOVA procedure with verbal mental age as a covariate. In addition to examining all main effects, we also examined the interaction between group and imitation type as the test of our main hypothesis, and examined the interaction between group and verbal mental age as a test of any unique relationships between groups for verbal functioning and imitation ability.

Results (presented in Figure 1) revealed a significant main-effect for imitation type (F (1,69) = 8.52, $p < .01$, $\eta^2 = .11$), with all subjects exhibiting better immediate imitation performance (Mean = .76, SEM = .03) than deferred imitation performance (Mean = .45, SEM = .03). There was no significant main effect for group (F (3,69) = 1.22, $p = .31$, $\eta^2 = .05$) and no interaction of task by group (F (3,69) = 1.53, $p = .22$, $\eta^2 = .06$). A significant main effect for verbal mental age was also found (F (1, 69) = 18.18, $p < .001$, $\eta^2 = .21$), but there was no interaction effect between group and verbal mental age (F (3, 69) = 1.08, $p = .36$ $\eta^2 = .05$). Thus, controlling for verbal mental age reduced group differences on the immediate imitation task. However, there was still no interaction of task by group, as predicted in our hypotheses.

Discussion

This study was designed to examine the performance of young children with autism on deferred imitation tasks compared to their performance on immediate imitation tasks, in order to examine further an inconsistency in findings in the first two published studies concerning deferred imitation in young children with autism (McDonough et al., 1997; Dawson et al., 1998). As in the first two papers, we constructed a set of tasks based on Meltzoff's method for examining deferred spontaneous imitation in toddlers (Meltzoff, 1988a, 1988b) and administered them in baseline and deferred (delay of one hour) conditions. We also administered a comparison set of immediate elicited object imitation tasks matched on difficulty, form, and salience. We examined preschool children with early onset autism and those with regressive autism, compared to children with other developmental delays, and those with typical development. We included these two autism groups based on onset pattern in response to previous findings of greater impairment in regressive subgroups in some previous studies and the possibility that differing onset patterns represent differing biological etiologies.

All groups of children demonstrated poorer performance in the deferred than in the immediate condition. This likely demonstrates the increased memory demand in the deferred condition, as well as other facilitating aspects of immediate elicited imitation tasks, such as engagement with the adult, motivation to imitate, and the facilitating aspects of a lab-based task administration (McDonough et al., 1997). However, the groups with autism demonstrated no greater impairment in the deferred condition than in the immediate condition, as shown by the lack of an interaction effect. This finding is consistent with previous studies of memory in autism that suggest deficits in organizational aspects of memory retrieval rather than specific long-term memory deficits (as reviewed by Tsatsanis, 2005).

We used extremely simple, means–end tasks for the imitation battery in an effort to design tasks that the children with autism could imitate, in order to examine the specific effects of delay on imitation performance. We were successful, as demonstrated by the lack of group differences on immediate imitation performance once we controlled for language differences. While the great majority of autism studies demonstrate impaired imitation performance in autism (reviewed by Rogers & Williams, 2006), the imitation deficit in autism is not an absolute inability (Rogers et al., 1996, 2003). The fact that children with autism can pass infant-level means–end imitation tasks far below their mental age has been previously demonstrated (Charman & Baron-Cohen, 1994, Hobson & Lee, 1999; McDonough et al., 1997). It is also important to note that our finding of a significant decrement in performance in the deferred imitation condition versus the immediate imitation condition validates one of the critical assumptions of our methodology – that deferred imitation is more difficult than immediate imitation. Given the sensitivity of our methodology to this imitation performance decrement between types of imitation, our methodology therefore provided a valid measure of any group differences in such a decrement.

One of our main findings was the lack of the predicted interaction of group by task, as well as lack of group differences. Our findings thus replicated the previous report by McDonough et al. (1997). We had expected relatively greater impairment deficit in deferred imitation in the autism group based on the relations between deferred imitation performance and measures of medial temporal lobe functioning in early autism, as reported by Dawson et al., (1998). We also hypothesized that the close relations between deferred imitation and symbolic play, both in theory (Piaget, 1962) and in empirical studies (Toth et al., 2006), would predict an autism-specific impairment in deferred imitation. However, there was no such interaction deficit. Given the long-term memory demands that are implicit in the deferred imitation task, our finding here of no autism-specific differences fits well with previous findings of no autism-specific differences in studies of long-term memory (Mottron et al., 2001; Renner et al., 2000).

Could the lack of the expected interaction be due to a flaw in the experiment? One question involves whether the possible ceiling effects in the typical group could have caused the lack of an expected interaction of group by task. However, since ceiling performance in the contrast groups involved immediate imitation rather than deferred imitation, the ceiling effect would only have masked a significantly better imitation performance in the typical group, and possibly a group by imitation type interaction. However, our hypothesis involved an interaction driven by poorer deferred imitation performance in the autism groups rather than an interaction driven by better immediate imitation performance in the comparison groups. We did not find poorer deferred imitation in the autism groups.

Our decision to control for differences in verbal age in the analysis represents a very conservative approach to the analysis. Since imitation and language ability are highly related in autism (see Toth et al., 2006 for a recent report), controlling for language ability also removes some of the variability associated with imitation. Decisions regarding group matching and controlling for group differences arise in every study of this type. Given the specific neuropsychological profile of children with autism, it is virtually impossible to assemble comparison groups who are equivalent to a young autism sample on chronological age, IQ, language ability, *and* nonverbal ability. In the present study, we chose the most conservative approach, based on the findings of Dawson et al. (1998) of group differences on very similar tasks in language matched groups. We are confident that such an approach would not mask real findings concerning our hypothesized interaction effect.

Our second main finding involved lack of differences in performance between the early onset and the regressive groups. This finding adds to recent literature exploring potential developmental, cognitive, and adaptive differences among children with autism as a function of their specific onset trajectory (Richler et al., 2006; Werner et al., 2005). Several recent studies have also failed to find differences between onset subgroups of autism (Davidovitch, Glick, Holtzman, Tirosh, & Safir, 2000; Tolbert, Brown, Fowler, & Parsons, 2001; Werner et al., 2005). The participants in our study were very young (mean age of 35.8 months); it is possible that group differences may emerge at older ages. Further study of the developmental trajectories of onset subgroups is needed, as well as broader examination of other cognitive and developmental skills.

When we examined the relationship between performance on immediate and deferred imitation tasks, we found significant and moderate correlations, very similar to recent reports by Toth et al. (2006). This supports earlier suggestions that the two sets of tasks share some aspects, likely those involved in imitating others' actions, and also taps somewhat different processes or mechanisms, perhaps involving representation and memory (McDonough et al., 1997; Dawson et al., 1998). The intriguing findings by Toth et al., (2006) of differential predictive relationships of immediate and deferred imitation on later development in autism highlight distinctions between immediate and deferred imitation.

One potential limitation of this study is the use of only one type of social context for the imitation, an instructional format. A second possible limitation is the potential confound involving use of elicited imitation for the immediate condition and spontaneous imitation for the deferred condition. Had we used spontaneous imitation tasks in both conditions, it would likely have decreased their immediate imitation performance but it would not have led to poorer deferred imitation, which was our hypothesis. Future studies should examine a wider range of tasks and social contexts (varying social familiarity, task complexity, and interpersonal style).

In summary, this study explored two main questions, one concerning the possibility that deferred imitation, relative to immediate imitation ability, was more severely affected in early autism than in comparison groups, and the second concerning possible effect of onset type on imitative performance. We found no evidence that deferred imitation was relatively more difficult than immediate imitation for young children with autism, and we found no effect of onset type on imitative performance.

Acknowledgements

This work was supported by grant # U19 HD35468-07 from the National Institute of Child Health and Human Development.

Correspondence to

Sally J. Rogers, M.I.N.D. Institute, UC Davis, 2825 50th Street, Sacramento, CA 95817, USA; Email: sally.rogers@ucdmc.ucdavis.edu

References

Charman, T., & Baron-Cohen, S. (1994). Another look at imitation in autism. *Development and Psychopathology*, *6*, 403–413.

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.

Collie, R., & Hayne, H. (1999). Deferred imitation by 6- and 9-month-old infants: More evidence for declarative memory. *Developmental Psychobiology*, *35*, 83–90.

Davidovitch, M., Glick, L., Holtzman, G., Tirosh, E., & Safir, M.P. (2000). Developmental regression in autism: Maternal perception. *Journal of Autism and Developmental Disabilities*, *30*, 113–119.

Dawson, G., Meltzoff, A., Osterling, J., & Rinaldi, J. (1998). Neuropsychological correlates of early symptoms of autism. *Child Development*, *69*, 1276–1285.

DeMyer, M.K., Alpern, G.D., Barton, S., DeMyer, W.E., Churchill, D.W., Hingtgen, J.N., et al. (1972). Imitation in autistic, early schizophrenic, and nonpsychotic subnormal children. *Journal of Autism and Childhood Schizophrenia*, *2*, 264–287.

Hobson, R.P., & Lee, A. (1999). Imitation and identification in autism. *Journal of Child Psychology and Psychiatry*, *40*, 649–660.

Hollingshead, A.B. (1975). *Four factor index of social status*. New Haven, CT: Yale University, Department of Sociology.

Learmonth, A.E., Lamberth, R., & Rovee-Collier, C. (2004). Generalization of deferred imitation during the first year of life. *Journal of Experimental Child Psychology*, *88*, 297–318.

Lord, C., Rutter, M., DiLavore, P., & Risi, S. (1999). *Autism Diagnostic Observation Schedule –WPS Edition*. Los Angeles, CA: Western Psychological Services.

Lord, C., Rutter, M., & Le Couteur, 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.

Luyster, R., Richler, J., Risi, S., Hsu, W.L., Dawson, G., Bernier, R., Hepburn, S., Hyman, S.L., McMahon, W., & Goudie-Nice, J. (2005). Early regression in social communication in autism spectrum disorders: A CPEA study. *Developmental Neuropsychology*, *27*, 311–336.

Mandler, J.M. (1990). Recall of events by preverbal children. *Annals of the New York Academy of Sciences*, *608*, 485–503.

McDonough, L., Stahmer, A., Schreibman, L., & Thompson, S.J. (1997). Deficits, delays, and distractions: An evaluation of symbolic play and memory in children with autism. *Development and Psychopathology*, *9*, 17–41.

Meltzoff, A. (1988a). Infant imitation after a 1-week delay: Long-term memory for novel acts and multiple stimuli. *Developmental Psychology*, *24*, 470–476.

Meltzoff, A. (1988b). Infant imitation and memory: Nine month olds in immediate and deferred tests. *Child Development*, *59*, 217–225.

Meltzoff, A.N., & Moore, M.K. (1992). Early imitation within a functional framework: The importance of person identity, movement, and development. *Infant Behavior and Development*, *15*, 479–505.
Mottron, L., Morasse, K., & Belleville, S. (2001). A study of memory functioning in individuals with autism. *Journal of Child Psychology and Psychiatry*, *42*, 253–260.
Mullen, E. (1989). *Mullen Scales of Early Learning*. Cranston, RI: T.O.T.A.L. Child, Inc.
Newschaffer, C.J., Croen, L.A., Daniels, J., Giarelli, E., Grether, J.K., Levy, S.E., Mandell, D.S., Miller, L.A., Pinto-Martin, J., Reaven, J., Reynolds, A.M., Rice, C.E., Schendel, D., & Windham, G.C. (2007). The epidemiology of autism spectrum disorders. *Annual Reviews in Public Health*, *28*, 235–258.
Nielsen, M., & Dissanayake, C. (2004). Pretend play, mirror self-recognition and imitation: A longitudinal investigation through the second year. *Infant Behavior and Development*, *27*, 342–365.
Ohta, M. (1987). Cognitive disorders of infantile autism: A study employing the WISC, spatial relationships, conceptualization, and gestural imitation. *Journal of Autism and Developmental Disorders*, *17*, 45–62.
Renner, P., Klinger, L.G., & Klinger, M.R. (2000). Implicit and explicit memory in autism: Is autism an amnesic disorder? *Journal of Autism and Developmental Disorders*, *30*, 3–14.
Piaget, J. (1962). *Play, dreams, and imitation in childhood*. New York: Norton.
Richler, J., Luyster, R., Risi, S., Hsu, W.L., Dawson, G., Bernier, R., et al. (2006). Is there a regressive 'phenotype' of autism spectrum disorder associated with the measles–mumps–rubella vaccine? A CPEA study. *Journal of Autism and Developmental Disorders*, *36*, 299–316.
Rogers, S.J., Bennetto, L., McEvoy, R., & Pennington, B.F. (1996). Imitation and pantomime in high functioning adolescents with autism spectrum disorders. *Child Development*, *67*, 2060–2073.
Rogers, S.J., & DiLalla, D. (1991). A comparative study of a developmentally based preschool curriculum on young children with autism and young children with other disorders of behavior and development. *Topics in Early Childhood Special Education*, *11*, 29–48.
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.J., & Williams, J.H.G. (2006). Imitation in autism: Findings and controversies. In S.J. Rogers & J.H.G. Williams (Eds.), *Imitation and the social mind: Autism and typical development* (pp. 277–309). New York: Guilford.
Stone, W.L., Ousley, O.Y., & Littleford, C.D. (1997). Motor imitation in young children with autism: What's the object? *Journal of Abnormal Child Psychology*, *25*, 475–485.
Tolbert, L., Brown, R., Fowler, P., & Parsons, D. (2001). Brief report: Lack of correlation between age of symptom onset and contemporaneous presentation. *Journal of Autism and Developmental Disorders*, *31*, 241–245.
Toth, K., Munson, J., Meltzoff, A., & Dawson, G. (2006). Early predictors of communication development in young children with autism spectrum disorder: Joint attention, imitation, and toy play. *Journal of Autism and Developmental Disorders*, *36*, 993–1005.
Tsatsanis, K.D. (2005). Neuropsychological characteristics in autism and related conditions. In F.R. Volkmar, A. Klin, R. Paul, & D. Cohen (Eds.), *Handbook of autism and pervasive developmental disorders* (3rd edn, pp. 365–381). Hoboken, NJ: Wiley and Sons.
Werner, E., Dawson, G., Munson, J., & Osterling, J. (2005). Variation in early developmental course in autism and its relation with behavioral outcome at 3–4 years of age. *Journal of Autism and Developmental Disorders*, *35*, 337–350.

Manuscript accepted 14 August 2007