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Another look at imitation in autism

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Abstract
Several authors have recently suggested that imitation may be a developmental "precursor" of a theory of mind and have linked impaired imitation in children with autism to their failure to develop a theory of mind. The present study investigated early-emerging procedural and gestural imitation abilities in children with autism. Children with autism were found to have intact basic-level gestural and procedural imitation. We discuss these results in terms of their relation to a specific developmental delay hypothesis of autism and re-assess the status of imitation as a developmental precursor of a theory of mind.

Several authors (Meltzoff, 1990; Meltzoff & Gopnik, 1993; Rogers & Pennington, 1991) have recently suggested that imitation may be a developmental "precursor" of a theory of mind and have linked impaired imitation in children with autism to their failure to develop a theory of mind (Baron-Cohen, Leslie, & Frith, 1985; see Baron-Cohen, 1993, for a review). The majority of studies conducted to date have concluded that children with autism are impaired in imitation, relative to mental age (MA)-matched controls (see Meltzoff & Gopnik, 1993, and Rogers & Pennington, 1991, for recent reviews). However, clinicians and teachers often express surprise at the idea of an imitation deficit, citing the fact that children with autism would not be able to benefit as they do from many educational programs without a capacity for imitation, because these almost always entail modeling by the teacher. The occurrence of echolalia is also often cited as clear evidence against an imitation deficit in autism. Although not a feature of Kanner's original description (Kanner, 1943), abnormal imitation has nevertheless become widely accepted as a feature of the syndrome. Thus, both the DSM-III-R (American Psychiatric Association [APA], 1987) and the ICD-10 (World Health Organization, 1992) include impaired imitation among the diagnostic criteria for autism. The present article reviews evidence for an imitation deficit and then reports our own study, which retests the imitation deficit hypothesis in autism.

Meltzoff (1990) summarized the three types of experimental research into imitation in normally developing infants as involving (a) *social modeling* (in which infants produce matching behavior of an adult), (b) *self-practice* (also called *deferred imitation*, or imitating after an extended delay), and (c) *social mirroring* (which occurs when infants recognize that an adult's behavior matches their own). Meltzoff argued that these form a developmental pattern re-

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flecting increasing memory load and representational complexity. Although substantial evidence indicates that the ability for social modeling is present in neonates (Meltzoff & Moore, 1983, 1989, 1992), evidence for the ability for deferred imitation of actions after a 24-hr delay has not been reported below 9 months of age (Meltzoff, 1988b), and social mirroring has only been demonstrated from 14 months of age (Meltzoff, 1990).

The experimental research in autism to date falls mostly into the category of social modeling. No studies have looked at the developmentally intermediate imitative ability of deferred imitation. The few studies that have investigated social mirroring have demonstrated that children with autism *do* recognize when their actions are being mirrored (Dawson & Adams, 1984). Social modeling studies have tended to use the *vocal* and *gestural imitation* items from the Uzgiris and Hunt (1975) sensorimotor development scales, or similar gestures (Curcio, 1978; Dawson & Adams, 1984; Jones & Prior, 1985; Morgan, Cutrer, Coplin, & Rodrigue, 1989; Sigman & Ungerer, 1984; Wetherby & Prutting, 1984). A few others have examined imitation of manipulation of objects (or *procedural imitation*) (DeMyer et al., 1972; Hammes & Langdell, 1981; Heimann, Ullstadius, Dahlgren, & Gillberg, 1992). Accordingly, these two forms of imitation in autism are reviewed next.

Gestural Imitation in Autism

DeMyer et al. (1972) found that subjects with autism were impaired, relative to MA-matched controls, in both imitation of body movements and actions on objects. Curcio (1978) found that while subjects with autism were able to solve object permanence tasks, their imitation of gestures, particularly facial gestures, was poor. Hammes and Langdell (1981) concluded that children with autism could perform imitation at the most basic level but were not able to imitate symbolic gestures. Sigman and Ungerer (1984) demonstrated autism-specific deficits in the execution of both motor and vocal imitation tasks from the Uzgiris and Hunt (1975) Sensorimotor Scales. Similar findings were obtained by Jones and Prior (1985) and Ohta (1987) using imitation of body movements. Dawson and Adams (1984) also found that while there was a range of imitative ability in their sample of children with autism, their performance on the imitation scales of Uzgiris and Hunt was significantly behind their performance on the object permanence scales. In addition, intact imitative responses were most likely for familiar (learned?) action patterns.

More recently, Rogers and McEvoy (1993) found that while high-functioning adolescents with autism were able to imitate familiar, meaningful (symbolic) movements, they were severely impaired, compared to controls, in imitating unfamiliar, novel actions. Heimann et al. (1992) also found a range of imitative ability in children with autism, and variability across a range of tasks, although the subjects with autism in their pilot study did not perform as well as chronological age (CA)- and MA-matched comparison groups. This is consistent with Hertzig, Snow, and Sherman (1989), who found that subjects with autism were poorer than control groups at imitating both sensorimotor and symbolic actions of a model.

On the other hand, several studies have obtained contradictory findings. Thatcher (1977) found that children with autism could pass the gestural and vocal imitation items from the Uzgiris and Hunt (1975) scales at a MA-appropriate level, although no comparison groups were employed in their study. Consistent with Thatcher's study, Morgan et al. (1989) also found no gestural or vocal imitation deficit in a group of children with autism, compared to matched controls. Morgan et al. (1989) suggested that their positive result may reflect the fact that their sample of children with autism were older (*M* CA = 101 months) and had a higher MA (*M* VMA = 36 months [V = verbal]) than the subjects employed by Sigman and Ungerer (1984). Could this account for variability in the results obtained over different studies? While Sigman and Ungerer's subjects were younger (*M* CA = 52 months) and less able (*M* MA = 25 months) than those in many of the studies reported, other studies that have demonstrated an impaired ability in children with autism have used older and more able subjects (DeMyer et al., 1972: CA = 67 months, VMA = 31 months; Curcio, 1978: CA = 97 months; Jones & Prior, 1985: CA = 103 months, VMA = 52 months; Rogers & McEvoy, 1993; CA = 186 months, VIQ = 85). On the face of it, therefore, neither CA nor MA appear to explain the variability of the results in imitation in autism. However, the possibility that the development of imitation in autism is significantly delayed but does eventually develop should not be discounted.

As mentioned earlier, most studies have employed the vocal and gestural imitation items from the Uzgiris and Hunt (1975) Sensorimotor Scales. The gestural imitation scale employs a hierarchy of tasks that increase in complexity and for which the age norms for passing range from 7 to 20 months. The lower items in the scale involve imitation of simple familiar gestures (e.g., clapping hands, age norm 7 months). In the middle of the scale, items involve imitation of unfamiliar, visible gestures (e.g., bending a finger to right angles, age norm 11 months). The higher items involve imitation of unfamiliar, invisible gestures (e.g., pulling down on one's ear lobe, hitting hands on the back of one's head, age norm 14–20 months). It may be that the positive results obtained by Thatcher (1977) and Morgan et al. (1989) reflect ceiling effects, as a result of the developmental limits of the Uzgiris and Hunt scales.

Procedural Imitation in Autism

We now turn to review the evidence concerning imitation of actions on objects (which, to reiterate, we call *procedural imitation*). This has been tested less frequently. DeMyer et al. (1972) selected motor-object imitation tasks from developmental assessment scales. These included a wide range of tasks such as stirring a spoon in a cup, buttoning two buttons, and kicking a ball. These are familiar gestures that are used in play and that the child may well have practiced and, indeed, have been encouraged to have performed, previously. DeMyer and her colleagues found that children with autism performed more poorly than controls on imitation tasks, particularly those involving imitation of body movements. More recently, Heimann et al. (1992) and Hammes and Langdell (1981) also have employed imitative acts, which involved functional and symbolic actions on familiar toys. Both studies found that while there was some variability in imitation ability, subjects with autism performed more poorly than controls. However, it is clear that these studies may confound familiar play routines with "pure" imitation and, hence, merge the boundaries between imitation and play. A poor performance on these tasks by children with autism may reflect abnormalities in either their functional or symbolic play (Baron-Cohen, 1987; Jarrold, Boucher, & Smith, 1993; Lewis & Boucher, 1988), rather than an imitation deficit per se. Alternatively, a good performance may reflect well-established play routines rather than imitative ability, similar to the demonstrated intact imitation of familiar and meaningful gestures already described (Dawson & Adams, 1984; Rogers & McEvoy, 1993).

Overall, the available evidence suggests that children with autism find gestural imitation more difficult than procedural imitation (DeMyer et al., 1972). To test this further, we designed a study to assess both of these types of imitation systematically. To avoid the problem of confounding procedural imitation and play, we used the tests of procedural imitation that Meltzoff (1988a, 1988b) developed in his work with 9-month-old normal children, which employ *unfamiliar* objects and which require *novel* actions to be imitated. In our opinion, these methodological features represent significant advances in the scientific study of imitation in development. Meltzoff demonstrated the validity of these tasks by using a "baseline" control condition, which involved the objects being presented with no action being demonstrated, and an "adult-manipulation" control condition, where the toy is picked up but where the target actions are not shown. (These tasks are described in detail later.) In contrast to the imitation condition, neither of these control conditions produced repetition of the critical imitative acts. Again, in our opinion, this rigorous methodology, and the specificity with which the acceptable response for imitation is defined, eradicates much of the confusion inherent in other studies where it is not clear whether imitation or some other response is being produced. Recent work with Down's syndrome children with a mental handicap using these tasks (Rast & Meltzoff, 1991) has indicated that their imitative skills develop in line with their MA. Such well-defined procedural imitation tasks have not been used previously with children with autism.

To summarize, the present study investigates the competence of children with autism and a control group of children with mental handicap on both gestural and procedural social modeling imitation tasks. To compare the results of the present study to previous research, we based the gestural imitation acts on the Uzgiris and Hunt (1975) Sensorimotor Scales. The procedural imitation tasks were those used by Meltzoff (Meltzoff, 1988a, 1988b).

The Experiment

Subjects

We tested 20 subjects with autism (16 male, 4 female), all of whom had been diagnosed according to established criteria (APA, 1987; Rutter, 1978). In addition, there were 23 subjects with mental handicap of uncertain etiology but without autism (9 male, 14 female), in order to control for MA and CA. Details of the subjects are summarized in Table 1. While there were no differences between the groups in terms of CA and VMA, the subjects with autism had a higher nonverbal MA (NVMA), ANOVA, $F(1, 31) = 36.7, p < .001$.

VMA was assessed using the Test of Reception of Grammar (TROG; Bishop, 1983), or the British Picture Vocabulary Scale (Dunn, Dunn, Whetton, & Pintillie, 1982) for those subjects who fell below the floor of the TROG (48 months). NVMA was assessed using Raven's Coloured Progressive Matrices (Raven, 1956), or the Merrill-Palmer Scale of Mental Abilities for those subjects who fell below the floor of Raven's matrices (42 months). Due to non-compliance, it was not possible to collect complete MA data for all subjects: VMA data was collected for 17 subjects with autism and 20 mental handicap subjects; NVMA for 16 and 17 subjects, respectively. Finally, one subject in the mental handicap group refused to take part in the gestural imitation trial.

Procedure

Each subject was tested in a quiet room in his or her school. After a short warm-up period, during which subjects played with a variety of toys, or were asked about what they had been doing at school that day (depending on which was most age-appropriate), subjects were given the procedural and gestural imitation tasks, in that order, in one session.

Procedural imitation. The materials and method for the procedural imitation task followed those described by Meltzoff (1988a, 1988b). The subject sat opposite the experimenter. Four imitative acts and objects were employed, all designed to be unfamiliar to the subjects:

1. The first object was a dumbbell-shaped toy that could be pulled apart and put back together again. The action demonstrated was to pick up the object by the wooden cubes and to pull outward, so that the toy came apart, and then to put the two pieces back together.
2. The second was an L-shaped hinge made of a flat rectangular base and a wooden flap that could be folded flat or to an

Table 1. *Subject variables: Means, standard deviations, and ranges of chronological age (CA) and mental age (MA) in months*

Diagnostic Groups	*n*	CA	Verbal MA[a]	Nonverbal MA[b]
Autism	20			
M		140.3	46.0	85.1
SD		49.9	15.7	24.2
Range		63–216	20–66	38–114
Mental handicap	23			
M		159.3	37.4	45.2
SD		44.2	15.35	11.8
Range		90–229	20–69	27–66

[a]Test of Reception of Grammar and British Picture Vocabulary Scale. [b]Raven's Coloured Progressive Matrices, Merrill-Palmer.

angle of 135°. The action demonstrated was to unfold the flap to its maximum angle and to return it to the flat position.

3. The third object was a small black box, with a recessed button on the top surface. The box was tilted by a support so that the top surface was facing the subject. The action demonstrated was to push in the recessed button, which produced a mechanical beeping sound.
4. The fourth object was another small black box, with a translucent panel on its top surface. The novel action demonstrated was for the experimenter to lean forward and touch the top panel of the box with his or her forehead, which illuminated the top panel of the box.

Each act was performed three times in a 20-s period. At the end of the four modeling periods (about 2 min in all), the subjects were given a sequence of four response periods of 20 s. The object was handed across the table and placed onto the table in front of the subjects. One nonspecific prompt ("What can you do with this?") was given if the subject failed to pick up or manipulate the object at once.

The following scoring criteria were adopted:

1. *Dumbbells:* To pass, the subject had to pick up the dumbbells by the wooden cubes and pull these outward, so that the toy came apart, and make some attempt (even if unsuccessful) to put the cubes back together again. If the subject picked up only one end of the dumbbells and they fell apart, or twisted them "head over heels," a fail was scored.
2. *Hinge:* To pass, the flap had to be pushed up by an angle of at least 45°. If the whole hinge array was picked up and manipulated in any other way, a fail was scored.
3. *Beeper:* To pass, the subject had to make a deliberate and successful attempt to activate the beeper by pushing on the recessed button. If the whole box was picked up and manipulated in any other way (even if this resulted in the button being pushed in the process), a fail was scored.
4. *Light box:* To pass, the subject had to illuminate the box by touching his or her nose/face/head to the surface of the box. If the box was picked up and manipulated in any other way (even if this resulted in the light being illuminated in the process), a fail was scored.

Gestural imitation. To test gestural imitation, we used a series of four actions closely based on the Uzgiris and Hunt (1975) Sensorimotor Scales and the imitative models described by Wetherby and Prutting (1984):

1. *Familiar action scheme:* Experimenter models hitting hands together.

2. *Unfamiliar visible gesture:* Experimenter models bending index finger to an angle of 90° with hand stretched out in front of face.

3. *Unfamiliar invisible gesture:* (i) Experimenter models pulling down on both earlobes with hands.

4. *Unfamiliar invisible gesture:* (ii) Experimenter models clapping both hands onto the back of his or her own head.

Each act was performed three times in a 20-s period, and at the end of each modeling period the subjects were given a 20-s response period, with the verbal prompt "Can you do that"? For a response to be counted as imitation, the subject had to carry out the *same* gestural routine within the 20-s response period. If, in addition, other actions were also carried out, the imitative gesture was still scored positively, because the acts were considered to be sufficiently unfamiliar and unusual and therefore unlikely to have occurred by chance.

Sixteen of the sessions were videotaped, and a second experimenter, naive to the aims of the investigation, rated whether imitation was present or absent for each procedural and gestural trial, using the preceding criteria. Inter-rater agreement was high. Measured in percentage terms, the mean agreement was 98.5% (range 94–100%) and as measured by Cohen's kappa (Cohen, 1960), the mean agreement was 0.96 (range 0.84–1.0).

Results

Summaries of the number of model acts imitated for both the procedural and gestural tasks and the mean scores (out of a possible total of 4) are given in Table 2. There were no differences between the mean scores of the autism and mental handicap groups on either the procedural or the gestural imitation tasks, ANOVA, $F(1, 42) = 0.48$ and $F(1, 41) = 0.05$, respectively, both $p > .10$. Neither was there a difference in their distribution of scores on either task (Kolmogorov-Smirnov test, both $p > .10$).

To identify subjects who reliably imitated, we used a cut-off of imitating three or more out of four acts. These data are presented in Table 3. In the autism group, only one subject failed to imitate reliably in both the procedural and gestural imitation tasks. In the mental handicap group, a few subjects found procedural imitation more difficult, but the difference between the two sets of trials was not significant, χ^2, $p > .10$. When we used a more conservative cut-off of imitating four out of four acts, a difference between performances on the procedural and gestural tasks did emerge for both groups. Eight subjects with autism failed to imitate reliably according to this criteria on the procedural imitation tasks, while only two did so on the gestural task, $\chi^2 = 3.3$, $p < .10$. In the mental handicap group, 10 subjects imitated unreliably on the procedural tasks against only 2 on the gestural tasks, $\chi^2 = 5.1, p < .05$.

We next examined differences in the age and ability of those who were reliable and unreliable imitators. Using the conservative scoring criteria adopted earlier, ANOVAs were carried out on the VMA, NVMA, and CA of the autism and mental handicap subjects, according to whether they were reliable or unreliable imitators. For the procedural tasks, there were no differences in VMA, NVMA, and CA between the reliable and unreliable imitators, for either group. However, for the gestural tasks differences were found for both groups. "Unreliable" imitators among the autistic subjects had a mean VMA of 20.0 months, against a mean of 49.5 months for reliable imitators, $F(1, 15) = 9.5$, $p < .01$. Among the mental handicap subjects, the unreliable imitators tended to have lower VMAs (*M*s 20.0 vs. 39.3 months, $F(1, 18) = 3.2, p < .10$) and NVMAs (*M*s 31.5 vs. 47.1 months, $F(1, 15) = 3.6, p < .10$) than the reliable imitators. Using the generous criteria for reliable imitation, of passing three or more trials out of four, mental handicap subjects who were unreliable imitators on the procedural tasks also had a lower VMA than those who were reliable imitators, *M*s 21.7 vs. 41.3 months, $F(1, 18) = 6.9, p < .02$.

Table 2. *Number of acts of procedural and gestural imitation produced by each group*

	N	0	1	2	3	4	*M*	*SD*
Procedural								
Autism	20	0	0	1	7	12	3.5	0.6
Mental handicap	23	1	0	4	5	13	3.3	1.1
Gestural								
Autism	20	0	0	1	1	18	3.9	0.5
Mental handicap	22	0	1	0	1	20	3.8	0.7

Table 3. *Percentage of subjects judged to be reliable imitators according to (i) generous and (ii) conservative criteria*

	Reliable Imitators	
	Procedural Tasks	Gestural Tasks
Generous criteria (pass three out of four trials)		
Autism	95%	95%
Mental handicap	78%	95%
Conservative criteria (pass four out of four trials)		
Autism	60%	90%
Mental handicap	56%	91%

Discussion

Children with autism demonstrated an intact ability to imitate on both the procedural and gestural tasks. That is, their performance did not differ from the group with mental handicap. Indeed, both groups performed near ceiling on the gestural imitation tasks and over three-quarters of the subjects imitated the modeled action correctly on at least three out of four procedural tasks.

These results differ from the set of studies (reviewed earlier) that have found that children with autism imitate less well than MA-matched controls (Curcio, 1978; Dawson & Adams, 1984; DeMyer et al., 1972; Hertzig et al., 1989; Jones & Prior, 1985; Ohta, 1987; Sigman & Ungerer, 1984). However, our results are consistent with the findings of intact ability to imitate by Thatcher (1977) and Morgan et al. (1989). The explanation offered by Morgan et al. (1989) for their discrepant result was the relatively high MA of their subjects, in comparison to studies where imitation in autism is found to be poor. Although in the present study the subjects with autism had a mean VMA that was higher than in some other studies (notably Dawson & Adams, 1984; DeMyer et al., 1972; Sigman & Ungerer, 1984), the sample is nevertheless comparable to several other studies where imitation was impaired (notably, Curcio, 1978; Jones & Prior, 1985; Rogers & McEvoy, 1993). Additionally, the range of VMA was wide; for example, the present sample included subjects with MAs as low as those taking part in the studies by Sigman and Ungerer (1984) and DeMyer et al. (1972).

Overall, the group with autism had a higher NVMA than the mental handicap controls, showing the classic dissociation between NVMA and VMA (DeMyer et al., 1972). However, intact imitation, at near ceiling performance, was demonstrated by the subset of subjects with autism with the lowest NVMA (NVMA below 60 months, $n = 5$), comparable to that of the mental handicap control group. One effect of MA was found, at the lower end of the range. The few subjects in either group who, by the exacting criteria of failure to imitate in all four trials, were coded as "unreliable" imitators tended to have a VMA of around 20 months. All subjects with a VMA above this level were coded as reliable imitators, even by this conservative estimate.

How does the performance of the two clinical groups in the present study compare to results from the normal developmental

iterature? Meltzoff (1988b) demonstrated intact procedural imitation in 9-month-olds, and the complex invisible gestures of the Uzgiris and Hunt (1975) scales have an age norm of 14–20 months. Rast and Meltzoff (1991) also demonstrated intact deferred procedural imitation in a sample of children with Down's syndrome aged 20–41 months. With the present sample, whose VMA is above 20 months, we are only able to conclude that neither group showed an imitation deficit. There is a clear need to test *younger* children with autism, in order to establish whether or not the age of acquisition of imitation in autism is normal, though this is hindered by the relatively late diagnosis of the condition. To this end, we are currently assessing imitation skills in 18-month-old children who are identified as having severe social-communication problems, some of which may include autism.

The alternative research strategy is to employ more developmentally complex imitation tests. The problem with this strategy is that the tests are likely to involve more complex sequences of actions, tapping executive functioning skills that are known to be impaired in autism (see Bishop, 1993, for a review). We would then be faced with a difficultly in disentangling any imitation deficit observed from an "executive" deficit.

Returning to the present study, it is of interest to note that of the 18 subjects from the two groups who failed to reach ceiling on the procedural tasks (12 of whom failed only one item), in all but one case the subjects failed Meltzoff's most "novel" imitation item—which cannot be passed by adopting a goal-oriented solution. In Meltzoff's (1988a) original study, the correct response to illuminate the box (touch with head) was the only response to never occur in the nonimitation control conditions, or spontaneously in play. This task may therefore be a better test of true imitation than the other procedural tasks employed, which may have an inherent goal-directedness and which may thus be solved without recourse to imitation.

For both the groups with autism and mental handicap, performance on the procedural tasks, while still high, tended to be worse than for the gestural tasks, contrary to both the finding of DeMyer (1976) and the findings from infants in the normal developmental literature (Meltzoff, 1988a; Uzgiris & Hunt, 1975). However, the results do not support the notion that the "social embeddedness" of the gestural tasks makes them more difficult than the procedural tasks for subjects with autism.

Several authors (Meltzoff, 1990; Meltzoff & Gopnik, 1993; Rogers & Pennington, 1991) have recently linked impaired imitation in children with autism to their failure to develop a theory of mind (Baron-Cohen et al., 1985; see Baron-Cohen, 1993, for a review). Thus, Meltzoff and Gopnik (1993) discussed the relevance of early imitation to the later development of a theory of mind: "[I]t provides the first, primordial instance of infants making a connection between the visible world of others and the infant's own internal states (pp. 337)." They suggested that children with autism may fail to develop imitation because of an impairment in their capacity for recognizing the cross-modal correspondences between their own movements and the movements of others. They argue that a disturbance in this early-developing, hard-wired ability would have serious consequences for a child's social-communicative development and, specifically, for the development of their theory of mind.

Rogers and Pennington (1991) developed a similar hypothesis, emphasizing the important role of imitation in the development of social reciprocity and intersubjectivity (Stern, 1985), affective sharing (Malatesta & Izard, 1984), and social learning (Bruner, 1975). In their model, imitation, emotion sharing, and theory of mind are increasingly complex expressions of the basic ability to form and coordinate representations of self and other.

The notion that imitation may be a developmental "precursor" of a theory of mind not only is important for theoretical reasons, but also opens the possibility that deficits in neonatal imitation ability may allow autism to be detected at a younger age than is presently possible. This would be important clinically, because currently the earliest predictors of autism are deficits in both pretend play and joint attention at 18 months of age (Baron-Cohen, Allen, & Gillberg, 1992).

Do the results of the study reported here pose problems for Rogers and Pennington's (1991) and Meltzoff and Gopnik's (1993) notion of imitation as a precursor of a theory of mind? On the face of it, their thesis would seem to be weakened by the findings of intact imitation in a group who from previous work we could expect to be impaired on theory of mind. The present results indicate that if the development of early-emerging imitation skills (which nevertheless involve invisible and unfamiliar gestures) are specifically delayed in autism, they are clearly not wholly absent. Other studies have demonstrated intact ability to imitate familiar, learned routine gestures (Dawson & Adams, 1984; Rogers & McEvoy, 1993) as well as a basic intact ability in the more developmentally complex process of social mirroring (Dawson & Adams, 1984). In addition, as mentioned in the introduction of this article, the use of motor imitation as a learning tool is widespread in intervention programs. In contrast, if we examine a different possible precursor of the development of a theory of mind – joint attention – children with autism of similar age and ability to those used in this study have recently been shown to have severe deficits on a gaze-monitoring task that is accomplished in normal development during the 1st year of life (Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1993). The severity of the joint attention deficits (which is manifested most dramatically in late teenagers with autism performing *worse* than normal 12-month-olds) makes it seem likely that a joint attention deficit is a more plausible precursor to the theory of mind deficit in autism (Baron-Cohen, 1989, 1991). The developmental relationship between early-emerging precursor abilities, such as imitation and joint attention, in autism and in normally developing children is nevertheless an important topic for future research.

However, to disprove the hypothesis that imitation is a *precursor* to a theory of mind, it would be necessary to document individuals who have an intact theory of mind in the presence of impaired imitation. We have not done this, and we know of no relevant data from elsewhere. Second, the imitation-as-precursor hypothesis may still be tenable if it could be shown that the present sample of children with autism were developmentally advanced enough to imitate, but still nevertheless *delayed* in this ability. Meltzoff has demonstrated competence on the procedural tasks in infants as young as 9 months old (Meltzoff, 1988a), and the age norm for passing even the most difficult of the gestural imitation tasks given by Uzgiris and Hunt is 20 months. The mean VMA of the subjects with autism in our study was 46 months, and only three subjects had VMA scores under 24 months. In this sense, a specific developmental delay hypothesis of imitation in autism is not ruled out. To test the delayed imitation hypothesis, we would need imitation tests that did not produce a ceiling effect, as ours have in this sample, or we would need to assess very young children with autism. However, we can conclude that to the extent that early-emerging imitation was found to be intact in the present study, if there are imitation deficits in autism at the infancy level, they are not found by late childhood.

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