7 Foundations for Developing a Concept of Self: The Role of Imitation in Relating Self to Other and the Value of Social Mirroring, Social Modeling, and Self-Practice in Infancy

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Questions about the origin and early manifestations of a notion of self have intrigued developmentalists since the founding of the discipline. Tiedemann (1787) and Darwin (1877) provided the first systematic notes on infancy. Among the issues explored by both was the question of when infants could first recognize themselves in a "looking glass" and begin fashioning a self-concept. Both were convinced that by about two years of age infants could recognize themselves and had developed at least a primitive notion of self.

Although it struck Tiedemann and Darwin that infants' reactions before the mirror provided a natural experiment in the psychogenesis of the self, neither was overly concerned about exactly what behaviors should be taken to indicate self-recognition. Tiedemann used the infant's seeming "pleasure" at mirror self-regard to determine that the twenty-one-month-old recognized "that is myself; those features are my own" (quoting from Tiedemann). A modern-day experimentalist would want to check that such "pleasure" would not also be exhibited to other faces with babyish features, inasmuch as these may be pleasing gestalten in themselves (Lorenz 1943), without the recognition that the babyish features belong to oneself. Darwin was intrigued by the dual facts that his infant son turned to look at himself in the mirror when his name was called and also that he systematically exclaimed "ah" when he saw his reflection. Today, we might wonder whether the child could just as easily have been trained to look at the parent in the mirror when the child's name was called. We might also inquire whether the "ah" was a greeting to any familiar face in the mirror, without recognition that the person in the mirror was, in fact, the self.[1]

1. These observers, Darwin especially, did not rely solely on the mirror task to draw inferences about infants' notions of themselves; but for many generations of investigators, the mirror situation became the quintessential task to evaluate the notion of self in the preverbal period.

Following Darwin and Tiedemann, many observers in the first half of this century explored when an infant seemed to recognize himself or herself in a mirror, but few (if any) devised a situation that showed with certainty that the infant apprehended the identity between the virtual self in the mirror and the true self that was the origin of this reflection. A breakthrough in mirror research came when Gallup (1970), using chimpanzees, and Amsterdam (1972), using infants, devised a new procedure for operationalizing self-recognition with a mirror. In Gallup's version, the subject's forehead and ear were unobtrusively marked with an odorless red dye, and self-recognition was indexed if the chimps looked in the mirror and then reached up to touch the marks on their own heads. This behavior was rare to nonexistent in marked chimps with no mirror and thus attributable to the chimpanzees using the information in mirrors to tell them about themselves. Gallup reported that among primates the only nonhuman species capable of succeeding on this mark task were chimpanzees and orangutans; all other primates so far tested have failed (Gallup 1982; Gallup and Suarez 1986).

Numerous studies have now adapted Gallup's technique and asked about the ontogenesis of mirror self-recognition in infants. The results show that infants exhibit self-recognition, as indexed by touching the mark, at about eighteen to twenty-four months of age but not before. The findings are quite consistent across several studies from independent laboratories (Amsterdam 1972; Bertenthal and Fischer 1978; Johnson 1983; Lewis and Brooks-Gunn 1979; Schulman and Kaplowitz 1977). Moreover, mirror self-recognition has been found to be delayed in children with Down syndrome, such that it emerges at a later chronological age than in normal children but when the subjects are approximately the same mental age or level of perceptual/cognitive sophistication (Loveland 1987; Mans, Cicchetti, and Sroufe 1978). This empirical convergence is certainly striking.

Given this area of settled data, it is tempting to infer that infants first develop the rudiments of a notion of self at about eighteen to twenty-four months. Such an inference may well be incorrect, however (see Butterworth, in this volume; Meltzoff 1985b). Mirror self-recognition is only one measure, one aspect of a broader concept of self, and it is possible to imagine that an infant who has begun to form a meaningful self-concept would still fail the mark test. The argument is not that Gallup's ingenious method is not a good test. It is just that it is not the *only* test of primitive self-awareness (Bower 1989; Gallup and Suarez 1986; Kagan 1981, 1984, 1989; Meltzoff 1985b; Stern 1985); and as I will argue in this chapter, when one expands the range of measuring devices, infants under eighteen months exhibit the foundations for a notion of self and some primitive apprehension about their basic similarity to others.

I want to underscore immediately what this argument is not: it is not a claim that young infants already possess a well-formed concept of self. Clearly, a

concept of self is greatly elaborated in early childhood and undergoes developmental changes for years afterwards, as described by others in this volume and elsewhere. The principal point I will try to make is that experiments can also be directed toward the initial origins of the notion of self—its foundation and earliest manifestation in the preverbal child. Recent studies of imitation and related phenomena in infancy provide new insights that complement the work that has already been done with mirror recognition. Moreover, because these newer studies involve infants younger than those used in the mirror test, they allow a glimpse of an even more embryonic notion of self than is reflected in the mirror studies. I will argue that these recent studies have uncovered aspects of the primordial notion of self from which subsequent development proceeds. By understanding the initial condition of the self during early infancy, we can better understand the subsequent critical developments that occur at eighteen to twenty-four months, when children are acquiring language and finally become able to recognize themselves in a mirror.

The new series of experiments described here used imitation as a tool for investigating infants' perception and knowledge about the self. Three different lines of experimentation were involved: they investigated "social mirroring," "social modeling," and "self practice."

In the first line of research, I adapted the traditional mirror studies but used an adult to act as a kind of social mirror to reflect the infants' behaviors back to them. This sidestepped some difficulties infants have in understanding the rather unique properties of a physical reflecting surface, and it revealed new facts about infants' apprehension of self-other similarities. In the second line of research, I investigated the capacity of infants to treat adults as social models, as sentient others whom infants can use as leverage in the early elaboration of self. Finally, in the third line of experiments, I explored how infants use imitation as a way of representing information to the self, of reenacting past events, and how this type of representation in action may affect subsequent cognitive representations of the self and the world.

My aim is to show that these three aspects of imitation—social mirroring, social modeling, and self practice—provide an important foundation for the development of self and a means by which we adults can catch a glimpse of the earliest workings of the self in the preverbal child. I will also argue that imitative interactions provide infants with a unique vehicle for elaborating the similarity between self and other and for understanding that others, like the self, are sentient beings with thoughts, intentions, and emotions. In other words, imitation may be an important, primitive building block in the nascent development of a "theory of mind" (Astington, Harris, and Olson 1988; Flavell 1985) in the child.

Adults as Social Mirrors: Seeing Oneself in the Actions of Others

When investigators use mirrors or photographs of the self to elicit self-recognition behavior, it is often the static featural information about the self that is being emphasized. A different tack is to inquire about self-recognition of actions and movement patterns.

If normal adults are allowed to watch their own hands move, they have no difficulty identifying the hand as their own. Indeed, they readily recognize the moving hand as their own even if it is featurally disguised by a glove. In contrast, when self-produced movement is eliminated and the purely static features of our own hands are captured in a photograph, it has been demonstrated that adults are surprisingly poor at recognizing their hands from among a group of other objects (Wuillemin and Richardson 1982). Evidently, to know something "like the back of one's own hand" is not a sterling achievement—at least when purely featural cues are isolated.

From a developmental perspective, this suggests that it might be useful to separate the growth of self recognition based on featural information from that of self-recognition based on spatiotemporal movement patterns. A self-recognition test using photographs addresses only the former. A typical mirror test assesses the former and possibly combines the two, for infants often sway or move while watching the image, thereby gaining both movement and featural information. To date, few tests have focused on the latter—on infant self-recognition as mediated by pure spatiotemporal movement patterns. This is unfortunate because there are good theoretical reasons for thinking that *the first, psychologically primary notion of self concerns not one's featural peculiarities but rather one's movements, body postures, and powers.*

How can we test infants' sensitivity for recognizing that human movements are "like me" in the absence of providing featural information about the self? Several approaches are possible; we chose one in which an adult experimenter acted as a kind of social mirror to the infant, reflecting back everything the baby did while, of course, not reflecting the infant's specific features. We wanted to know if infants could recognize this self-other similarity in the absence of featural identity. Because we believed this ability would develop prior to solving the mark test, which relies on physical mirrors, we tested infants at fourteen months of age.

A series of three experiments was conducted, each designed to isolate in successively greater detail the nature and basis of infants' ability to recognize when their own behavior was being reflected back to them by another. The first experiment asked at the most basic level whether or not infants showed any such recognition. Twenty-eight infants fourteen months old served as subjects. The procedure involved two experimenters sitting side by side across a table from the subject. One experimenter was assigned the task of

shadowing the infant, immediately imitating everything the child did with his or her toy. When the subject banged the toy three times, the experimenter banged his three times; when the subject mouthed the toy, the experimenter did likewise. The second experimenter was the control, sitting passively and holding a toy loosely in her hands on the table top. The two experimenters and the infant were each given an identical toy at the beginning of each trial. Each trial was forty-five seconds in duration; and the experiment consisted of a series of seven such trials, each with a different toy. In short, there were three participants, each with the identical-looking toy; one experimenter continuously imitated the infant across seven trials, and the other passively held the same kind of toy as used by the other two. The experimenter who acted as imitator, the side (right/left) on which the imitator sat, and the order of test objects were counterbalanced across infants. The infants' behavior was video-recorded and subsequently scored by observers who could not see the experimenters and thus had no artifactual cues as to which experimenter was imitating the infant.

We thought that if infants could detect that their own actions were being duplicated, they would prefer to look at the imitating experimenter and also smile at him more. We also predicted that they would tend to ''test'' whether the adult was acting as a social mirror by investigating the self-other relation in special ways. For example, the infant might stare at the adult as the infant carefully produced a behavior; the infant then might modulate his act by going faster and faster to check if the experimenter was shadowing him, or suddenly stop to see if the experimenter stopped. In short, the infant was presented with the same situation as Harpo Marx and a variety of actors since, in which an actor facing a mirror must determine if the image is really his own: does it stroke its chin when he strokes his, shave when he shaves, and so forth? The actor typically engages in odd actions: slowly moving his hand while staring at the mirror image, then waving it, then sharply deviating from one motion to another to check if the image does the same. We thought the infant might act in a similar manner and the scorer, who was blind to which side the imitating adult was on, recorded all instances of such testing behavior from the video record.

The results show that infants looked significantly longer at the imitating adult than at the control ($p < .001$). Similarly, more smiles were directed toward the imitator than toward the control ($p < .001$), and infants directed more test behavior at the imitator than at the control ($p < .01$).

One interpretation of these results is that infants can recognize the self-other equivalence that is involved when an adult imitates them. Alternative interpretations are also possible. It is plausible, on the basis of experiment 1 alone, that infants are simply attracted to adults who actively manipulate toys. This could explain why they look longer and smile more at the imitator than at the passive control, without invoking any detection of action equivalence. Such an interpretation is more strained to account for why infants would show a

tendency to test the imitating adult, but one might hypothesize such behavior is displayed to any active adult, whether or not the adult is mimicking the baby.

In experiment 2, the general procedure was identical to the first study, except that the control experimenter did not remain passive. Instead, this adult actively manipulated the toy. Furthermore, we wanted the experimenter not only to be active but to do "babylike" things with the toy, so that no preference for the imitating experimenter could be based solely on a differentiation of adult versus infantile actions. This was achieved by using a yoked control procedure. The room was arranged such that there were two TV monitors situated behind the subject and in view of the experimenters. One monitor displayed the actions of the current infant, live. The other monitor displayed the video record of the immediately preceding subject.

The effect was that both experimenters were actively imitating infant behaviors and thus were good controls for one another; but in relation to the infant, one was a "self-imitator" and the other an "other-imitator." The experimental question was whether the infant could recognize which adult was acting like he/she was. Fifty-six fourteen-month-olds served as subjects. The results showed that infants again succeeded on the task. Infants looked longer at the self-imitator ($p < .05$), smiled more often at him ($p < .001$), and, most important, engaged in more testing with the self-imitator than with the other-imitator ($p < .01$).

This experiment constrains the possible interpretations of the phenomenon. The demonstrated effects cannot be explained as simple reactions to activity versus nonactivity, for both experimenters were active. Nor can they be explained as recognizing a generic class of babylike actions, for both experimenters were copying the acts of babies. It would seem that the subjects were recognizing the relationship between the actions of the self and the actions of the imitating other.

What is the basis for detecting this relationship? Broadly speaking, two classes of information are available. The first is purely temporal contingency information. According to this alternative, the infant need only detect that when he does X, the adult does Y. The infant need not detect that X and Y are in fact equivalent, only that they are temporally linked. The second alternative is that the infant can also recognize that the actions of the self and other are structurally equivalent. How can we separate these two alternatives?[2]

In experiment 3, we tested another fifty-six normal fourteen-month-olds, using a design similar to the previous two experiments. In this study, the purely temporal aspects of the contingency were controlled by having both experimenters act at precisely the same time. This was achieved by having three predetermined pairs of "target actions." Both experimenters would sit

2. Note that these alternatives are not separated in the classical studies using mirrors, because the mirror image is both moving contingently and in the same structural manner as the self.

passively with the toy until the infant performed one of the target actions on this list. If the infant exhibited one of these target actions, both experimenters would immediately begin to act. The imitating experimenter would perform the infant's act, and the control experimenter would perform the other behavior that was paired with it from the predetermined target list.

Let me make this more concrete. The three pairs of actions were (*a*) shake = slide, (*b*) pound = poke, and (*c*) touch mouth with toy = touch nonoral region on the head, neck, or shoulders. These pairs were chosen from an extensive video review that showed that these were six common "action schemes" of infants this age and that the acts within each pair were similar. In the experiment, whenever an infant shook a toy, the imitating experimenter would also shake his toy, carefully shadowing the infant. The experimenter's behavior was thus under the complete control of the infant. However, the behavior of the other experimenter was also under complete temporal control of the infant. Whenever the infant *shook* his toy, the control experimenter would *slide* his matched toy, also carefully shadowing the infant so that he matched the temporal envelope of the subject's behavior. In sum, whenever the subject shook a toy, he saw a paired-comparison display of two adults acting: one was shaking a replica of his toy; the other was sliding the replica. As soon as the infant stopped, both experimenters stopped; and as soon as the infant started shaking again, the experimenters again started shaking and sliding, respectively. If the infant stopped shaking and began waving his toy, both experimenters stopped acting in unison, because waving was not one of the target acts to which they were programmed to respond. Note that the target pairs were fully reciprocal in that whenever the infant either shook or slid his toy he saw both shaking and sliding—it's just that the experimenter who performed these acts would reverse if the infant changed from one action to the other, because the imitating experimenter always matched the infant's behavior and the control experimenter always mismatched it. Table 1 displays the set of contingencies presented to the infant.

Table 1. Stimulus-Response Contingencies Presented in the Social Mirroring Experiment

Infant's Behavior	Imitating Experimenter	Control Experimenter
Shake	Shake	Slide
Slide	Slide	Shake
Pound	Pound	Poke
Poke	Poke	Pound
Mouth	Mouth	Head, neck, shoulder
Head, neck, shoulder	Head, neck, shoulder	Mouth
Other	Passive	Passive

This design achieves the goal of having both the adults' actions contingent on the infant's. What differentiates the two experimenters is not the purely temporal relations with the acting subject but the structure of their actions vis-à-vis the subject. One adult consistently matches the structure of the infant's behavior; the other adult consistently mismatches it. The experimental question is whether this self-other relation is psychologically salient to the infant.

The results show that the infants looked ($p < .05$) and smiled ($p < .001$) more at the matching than at the mismatching actor. Most important, the infants directed more testing behavior to the matching actor ($p < .01$). These results show that, with temporal contingency information controlled, infants can recognize the structural equivalence between the acts they see others perform and the acts they do themselves. In that sense, they have already begun to elaborate a notion of self which, if not based strictly on a visual self-image, consists of a kind of extended "body scheme"—a system of body movements, postures, acts, and their relation to like behaviors by others. This recognition of the equivalence between self and other in infants as young as fourteen months old (prior to success on the classic mirror "mark" test) is important for theories of social development, as will be discussed later in this chapter.

Adults as Social Models

In the studies just discussed, the situation was arranged so that the adult acted as a kind of social mirror. The emphasis was on infants' ability to recognize matches *of* the self. A complementary skill is the ability to produce matches *by* the self. If the first case is one of social mirroring, the second is one of social modeling. The adult becomes the model which the infant tries to match, to imitate.

It is broadly agreed that at some stage in development the imitation of others plays a role in the growth of the self, its skills and proclivities. Children learn to speak Arabic rather than English and become enculturated to that way of life at least in part through imitation of adult models. The abilities of the self, the roles we take on, the standards to which we adhere are influenced by social models. In brief, imitation is relevant to self development because it is a process by which something of the other is taken on by the self (Baldwin 1906; Bandura 1986; Kagan 1981; Mead 1934).

From the perspective of early self development, one intriguing question is whether infants can acquire new behaviors merely from watching another act. This is a question of the imitation of novel acts. We want to know if infants are constrained to imitating only actions that are highly familiar to themselves or whether the self-other mapping is so facile that the infants can learn

something about his or her own body and its possible actions simply by observing the behavior of another. Especially relevant is the imitation of novelty after a lengthy delay. If the infant is limited to immediate mimicry, imitation can play only a limited role in broadening the self's repertoire and in long-term changes in the self. For imitation to be of more value, infants must have some sort of representational capacity, allowing them to "read out" at a later time the information previously picked up from the other. The developmental literature terms this "deferred imitation."

We conducted a study in which infants were tested to see if they could imitate a range of behaviors, including at least one novel one, after quite lengthy delays were imposed (Meltzoff 1988b). The subjects were thirty-six healthy fourteen-month-old infants. The delay interval was one week. The infants were exposed to an adult who performed a series of acts on different toys during the first visit to the laboratory; then a one-week delay was imposed before infants were brought back to the laboratory and given access to the toys. The experimental question was whether they themselves would now perform those acts exhibited by the adult actor one week earlier.

Six objects were selected so that none would be overly familiar to the infants. One object was a small box with a plastic orange panel for a top surface. The novel act demonstrated by the experimenter was to lean forward from the waist and tap the panel with the top of his forehead. The second object was a dumbbell-shaped toy; it consisted of a short section of double tubing with one section inside the other and cubes attached to the ends. The action demonstrated by the adult was to pick up the object by the cubes and to pull it apart. Four other objects and the simple acts performed on them completed the set of six stimuli.

The subjects were randomly assigned to one of three test conditions: baseline control, adult-manipulation control, and imitation. The design consisted of two test sessions, one week apart. The following is a description of the procedure used in the first test session. In the imitation group, each subject was sequentially shown the six target actions. Each demonstration consisted of a twenty-second period in which the target action was repeated three times. For example, the experimenter leaned forward and touched the panel with his forehead and then straightened up, repeating this three times. The demonstrations were presented on the tabletop out of reach of the subjects, so that they could only observe the event, not touch or play with the toys.

In order to isolate true deferred imitation, two control groups were used to check whether infants would tend to produce the target actions even without any exposure to the adult model. Infants assigned to the baseline condition came to the laboratory for a first visit and sat across the table from the experimenter while he talked to the parent. This helped acclimate them to the test room, just as the infants in the imitation group had been brought into this room in session 1. These infants were then sent home and returned one week later.

Infants in the imitation condition saw the experimenter pick up and manipulate the test objects. It is possible that simply seeing the adult handle the test objects motivates infants to manipulate the objects when they are subsequently presented in the second session. Such active, exploratory manipulation might in turn lead the infants to produce the target actions by chance. The baseline control does not provide a stringent check of this type of nonimitative production of the target actions; thus, a second type of control is also desirable. In this adult-manipulation condition, the subjects were exposed to a series of six stimulus-presentation periods just as the imitation group had been. For each presentation, the experimenter reached out and manipulated the test object just as he had done for the imitation condition, save that he did not exhibit the target act. As in the imitation condition, the presentation lasted twenty seconds, and the control manipulations were performed three times in the twenty-second period. The inclusion of this control condition tests for the possibility that infants are simply induced to produce the targets for nonimitative reasons, because they see the toys handled by the experimenter. Using this design, the inference of imitation is warranted if subjects differentially produce more of the specific target acts after seeing those acts modeled than in the two controls.

Subjects in all three groups (baseline, adult-manipulation, and imitation) were treated identically on the second visit. The test objects were simply re-presented in their original test order. Each object was placed on the table in front of the infant, and a twenty-second response period was timed for each object, starting from the moment the infant first contacted the toy. The infants' behavior was video-recorded and subsequently scored by observers who remained naive as to the subjects' original test conditions.

Each subject was given six test stimuli and thus assigned a score (0–6) according to the number of target behaviors produced. The results were analyzed using a 3(condition) × 2 (sex) ANOVA. The main effect for condition was significant, $F (2,30) = 12.00, p < .001$. There was no main effect for sex and no condition × sex interaction, F's < 1. A Newman-Keuls test showed that infants in the imitation condition produced significantly more target behaviors ($M = 3.42$) than those in either the baseline ($M = 1.25$) or the adult-manipulation controls ($M = 1.67$). There was no significant difference in the number of target behaviors produced by the two controls. The strength of the imitation effect is shown in table 2, which provides a raw data matrix of the number of target acts performed as a function of experimental treatment, $\chi^2(10) = 24.46, p < .01$. As shown, eleven of the twelve subjects in the imitation condition duplicated three or more target behaviors, while only three of the twenty-four control subjects did so—thus providing clear evidence for the modeling effect ($p < .0001$).

Did infants imitate the novel act of touching the orange panel with their foreheads? The data indicate they did. First, the data show that head touching

Table 2. Number of Subjects Producing Different Numbers of Target Acts as a Function of Test Condition

| | Number of Target Acts Produced | | | | | | |
Test Condition	0	1	2	3	4	5	6
Baseline control	3	4	4	1	0	0	0
Adult-manipulation control	2	4	4	0	2	0	0
Imitation	0	1	0	6	3	2	0

Note: Maximum score = 6.

is indeed a novel act in that it simply was never performed by any of the control infants: none of the twenty-four controls leaned forward and touched the panel with their heads. Nonetheless, 67 percent of the infants who saw head touching produced this action ($p < .0001$). That infants observed this rather odd action and then ''read it out'' in their own actions after a one-week delay attests to the long-lasting effect of social modeling on infants. The experiment thus provided a good case of infants directly picking up a behavior from seeing it performed by another.

It is of interest for theories of cognitive development that these fourteen-month-olds exhibited deferred imitation of novelty without a period of trial-and-error groping in the second test session. For the children who successfully performed the head-touch gesture on the second session, the mean latency to produce the head touch was 3.21 seconds. The inference is that upon seeing the demonstration in the first session, infants were able to represent this new act in long-term memory even though it did not fit in with a habitual motor pattern of their own. Infants were able to accommodate their mental scheme internally, before and without any motor practice or what Piaget (1952) called ''directed groping.'' This is relevant because this type of deferred novel imitation is often cited as a constituent of a global psychological shift at about eighteen to twenty-four months of age, the so-called ''sensorimotor stage VI'' (Piaget 1962). The current work does not definitively address this idea of a global ''stage VI'' cognitive shift, because measures of the putatively related skills (object permanence, productive language, symbolic play) were not also recorded on these same subjects. However, the results show that a robust capacity for deferred imitation is present early in the second year, a finding recently replicated with even younger (nine-month-old) infants (Meltzoff 1988c), and this is well before other developments have been typically observed. I have proposed that the ability to defer imitation of the acts of others is psychologically quite basic and does not emerge as a late achievement, contemporaneously with other aspects of the ''symbolic function'' (Meltzoff, 1985a, 1985b, 1988a).

From a social-developmental viewpoint, it is noteworthy that the design involved showing infants a series of acts in sequence and only then allowing them to respond. Thus, infants were confined purely to watching during the modeling period and did not have access to the toys. It is striking that so many different acts could be remembered and read out one week later ($M = 3.42$), especially in view of the fact that each demonstration lasted only twenty seconds. The results invite speculation about how such a capacity might be of service in everyday life. Consider that parents and especially other children do not always allow infants access to one toy before showing other potentially competing acts with different toys. The current findings show that even young infants can hold in mind more than one event for subsequent reproduction once they get access to the toy. This strongly suggests that imitation and social learning could be functional between infants and their peers, siblings, and other real-world models who do not allow response before proceeding to display other acts. Indeed, recent work in our lab has demonstrated imitation among fourteen-month-old peers, confirming that infant models, as well as adult models, influence infant behavior during this age period (Hanna and Meltzoff 1989, 1990).

Imitation and "Self Practice": The Value of Imitation for the Self

The previous study was intentionally designed such that infants were confined solely to observing the social model. While this embodies a rather pure case of deferred imitation, observations of parent-child interactions reveal that parents often simplify their own behavior patterns and encourage infants to attend to/imitate one constituent of a complex skill before moving on to the next component (Bruner 1973, 1975, 1983). One's curiosity is piqued as to why this is such a "natural" mode of pedagogy.

The possibility arises that giving infants a chance to imitate an act immediately after it is shown may help them to consolidate that behavior. If so, subsequent reproduction of the behavior might be especially robust if such consolidation is permitted *before* the delay is interposed. On this view, one function served by early imitation would be to incorporate an observed act solidly into one's own repertoire, to commit it to memory. This idea can be operationalized and reduced to test by comparing two groups of infants. Infants in one condition would be treated as in the previous study, in which no imitation was allowed before the lengthy delay. Infants in the other condition would be given the opportunity for immediate imitation, before the delay was imposed. The question under test would be whether or not these two treatments had an effect on infants' tendency to duplicate the target after the delay.

The subjects used to test this question were a new group of forty-eight normal fourteen-month-olds. The stimuli were two objects, an orange plastic egg that made a rattling sound when shaken and a small stuffed animal that could be dangled on the tabletop by an attached string. Infants were randomly assigned to one of the two different types of deferred conditions, each with twenty-four subjects.

The procedure entailed two visits to the laboratory. In group 1, infants were shown the two target acts but not given the opportunity for immediate imitation. The first target was demonstrated, then that object was removed and the other target act was then demonstrated with the second toy. The infants then were sent home for the twenty-four–hour delay. Infants in group 2 followed a slightly different procedure. After the first target was demonstrated, the infant was given the object for a twenty-second response period, thereby permitting immediate imitation of the adult display. The same procedure was then followed for the second object.

In the second session, infants from both groups were treated identically. The infants simply were presented with the test objects, one at a time, each for a twenty-second response period. The infant's behavior during this period was video-recorded and subsequently scored by observers who were naive to the infant's test condition.

Infants received a score of 0, 1, or 2 according to how many targets they produced. A chi-square test revealed that these scores varied as a function of test condition, with infants in group 2 producing more of the target behaviors than those in group 1; indeed, infants in group 2 were twice as likely to produce both target gestures as infants in group 1 (50 percent versus 25 percent, respectively).

The present study thus shows there is a difference in the strength of imitation after a one-day delay as a function of whether infants (*a*) were constrained solely to observing the adult's actions on day one (group 1) or (*b*) observed the adult's actions on day one and also were given access to the toys and allowed to engage in on-line immediate imitation before the delay was instituted (group 2). Something appears to be gained if infants are given the opportunity for imitation immediately after seeing the adult modeling.

My interpretation of these findings is that immediate imitation serves the function of a kind of nonverbal rehearsal for the infant, raising the possibility that imitation is not only a tool for the experimenter to assess infant memory after a delay but also a means by which infants enhance their own memory of behaviors they see. The data from previous studies amply documented that infants are influenced by the actions of others. The additional point made by this study is that infants are given a boost if they quickly incorporate an observed act into the self's system of actions—as, for example, under the group 2 procedure. As conceived here, imitation is a repetition of a perceived event by the self; it is a type of self practice and, as such, is one tool infants have

for consolidating the memory of an event for themselves. It is a way nonverbal infants have of taking something of the other and making it their own.

Games Infants Play and Their Relation to Social Mirroring

One common observation about early parent-infant games is that they are often reciprocally imitative in nature. First, the infant begins with an act of banging a tabletop. The parent seizes the opportunity for making a communicative connection and bangs in return. Next, the child repeats the same, then the parent, and so on, in a kind of nonverbal-exchange game. Theorists have been struck by the *temporal patterning* of these exchanges, the conversation-like turn-taking they embody; and a variety of hypotheses about social development have emerged to incorporate them (Brazelton and Tronick 1980; Bruner 1975, 1983; Papoušek and Papoušek 1986; Stern 1985; Trevarthen and Marwick 1986).

Our recent experiments on social mirroring provide an additional perspective on these everyday observations. Without taking away from the temporal side of the exchange, our experiments bring to the forefront the equivalence in the *form* of the participants' behavior. The results from our social mirroring studies demonstrate that when temporal contingency information is equated, infants still can detect when the structure of their own actions is being matched. Moreover, and of more relevance to the games under consideration, the experimental results show that infants prefer to look at an adult who is matching them, and they also smile more at him or her.

On the basis of these results, I would suggest that, in addition to finding pleasure in the temporal patterning of adult exchange games, infants also may take delight in the fact that the parent is acting as a kind of social mirror. Indeed, in these everyday games, parents are performing exactly as the imitating experimenter in our social mirroring study. As our experiment shows, one easy way to attract the infant's attention and to elicit smiles is to act like the baby acts, which is just what the adult partner does in these games. Following this reasoning to another communicative channel, it is also worth considering the vocal phenomenon of "motherese," in which adults speak in a high-pitched voice while talking to infants. Recent cross-language work shows this is probably a culturally universal phenomenon (Grieser and Kuhl 1988). It would be interesting if one reason infants find the high-pitched motherese signal so captivating is that the pitch is closer to the infants' own register than is normal, adult-directed speech. Parental vocal games spoken in motherese may be providing, in the vocal channel, something akin to the social mirroring I have discussed here in terms of gestural acts. (For data and arguments regarding the acoustic salience of motherese for infants, see Fernald and Kuhl 1987; Grieser and Kuhl 1988.)

The Developmental Origins of Social Modeling Effects

In social mirroring, the adult is doing most of the productive work. The adult is busily shadowing the infant, and the infant need only recognize that his or her behavior is being matched. Because recognition runs ahead of production in many aspects of development, the possibility may be raised that social mirroring is the primordial imitative relationship. Perhaps infants first learn to imitate others by having others imitate them.

Cast in the terms of this chapter, this issue concerns the developmental priority of social mirroring versus social modeling. At a more general theoretical level, it is a question of the degree to which the "other" gives structure to an initially meaningless self. Such a question has been addressed by many writers, notably Baldwin (1906), Cooley (1902), Mahler, Pine, and Bergman (1975), Mead (1934), and Piaget (1952, 1954). I believe that our recent data also bear on it. Looking at it as a developmental issue amenable to experiment, we may ask: How much and what type of experience in interacting with an adult other is necessary for the infant to apprehend self-other equivalences? Is experience with social *mirroring* necessary for infants to respond to social *modeling*? Theories at the extreme of assuming no sense of self in early infancy and those postulating a lead role for the other in the infant's construction of self have suggested that infants first learn to imitate others by virtue of the fact that sensitive parents initially act as a kind of biological mirror and imitate the infant. The infant is thought to learn to imitate through at first being imitated. This postulate can be tested, and we have done so.

Social Modeling Effects in the First Year

In the studies previously discussed, fourteen-month-olds served as subjects; this gives parents ample opportunity for engaging in social mirroring games. We wanted to trace infant imitation to an earlier age, before such games become so popular. A further study was therefore conducted, using nine-month-old infants (Meltzoff 1988c). Sixty subjects were seen in an immediate imitation test, and sixty in a deferred imitation test using a twenty-four–hour delay. The tasks used were three simple actions with novel objects. The design used was one in which infants were not given access to the toys during the modeling episodes (a "group 1" design). Appropriate control groups, both baseline and adult-manipulation, were employed.

Infants' responses were scored from video record by observers who were blind to the subjects' test conditions. Each infant was assigned a score reflecting how many target actions he or she produced. A condition $\times$ delay ANOVA showed that the main effect for condition was significant, $F(3,112) = 10.39, p < .001$, and a planned comparison showed that infants produced

significantly more of the target behaviors in the imitation condition than in the controls, t (116) = 5.22, $p < .0001$. There was no delay effect and no condition $\times$ delay interaction, F's < 1.

This study shows that infants as young as age nine months will imitate simple actions using novel toys both immediately and after a twenty-four hour delay. Social modeling influences infant behavior even over quite lengthy delays in children well under one year of age.

Social Modeling Effects in the First Month

So far, we have considered the imitation of object-directed behaviors. A different type of imitation is the copying of pure body movements without objects (e.g., the imitation of facial gestures). For such imitation, the subjects must translate the body transformations they see into body movements of their own with no external object beyond the movement pattern itself playing a role. Classic developmental theory predicts that the imitation of pure body movements is highly constrained in infancy, with implications for theories about the development of self. The onset of spontaneous facial imitation is predicted to occur at about one year of age (Piaget 1962). Before this age, infants are thought to be unable to match a gesture they see with one of their own that they cannot see, unless specifically shaped to perform such tasks. In 1977, we conducted two studies investigating facial imitation in two- to three-week-old infants (Meltzoff and Moore 1977).

In this work, we wanted to be careful to distinguish infants' imitative responses from global arousal responses, and controls were instituted to accomplish this. For example, suppose an experiment was designed with a baseline period in which no face was presented, and this was followed by a tongue-protrusion demonstration by an adult experimenter. Further suppose that there were significantly more infant tongue protrusions to the adult tongue display than during the baseline condition. Such results would not permit the inference of infant imitation. Infants might be aroused at the sight of a moving human face, and infant oral movements including tonguing could be part of this general arousal response.

To address this problem, we used a "cross-target" comparison (Meltzoff and Moore 1977, 1983b) in which infants were shown several gestures (targets) in a repeated-measures design and their responses across these different targets were monitored. For example, we showed an infant both a mouth-opening display and a tongue-protrusion display. If infants responded with more mouth opening to the mouth display than to the tongue display and, conversely, responded with more tongue protrusions to the tongue display than to the mouth display, this could not be due to a general arousal. Both gestures were presented by the same experimenter, at the same distance, and
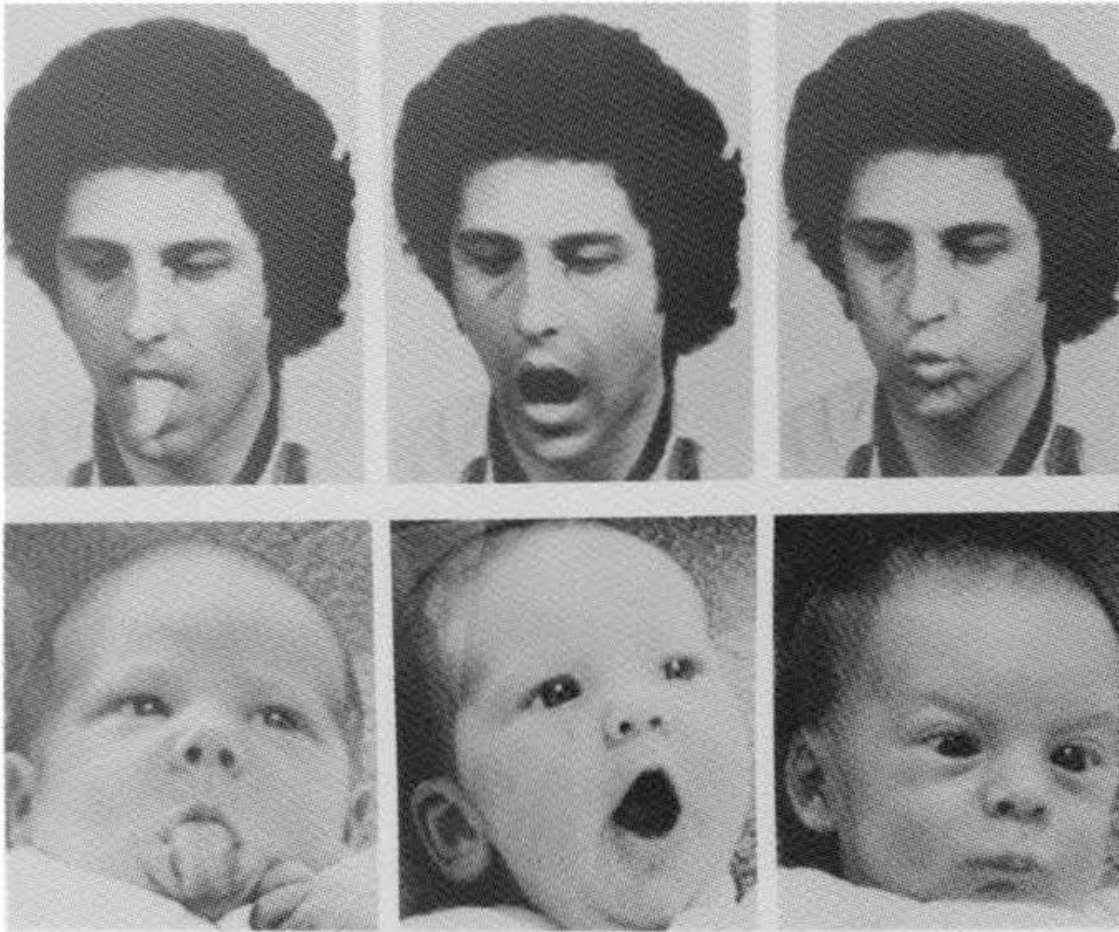
Figure 7.1. Sample photographs of two- to three-week-old infants imitating facial gestures demonstrated by an adult. From A. N. Meltzoff and M. K. Moore, Imitation of facial and manual gestures by human neonates, *Science* 198 (1977): 75–78.

at the same rate of movement. The differential matching response to both displays cannot be explained by a general arousal response.

Following this logic, we conducted two studies. Although the designs were slightly different, they both yielded evidence for facial imitation in infants less than three weeks old (figure 1). In the first study, twelve- to seventeen-day-old infants were each shown four gestures in a repeated-measures design. The four gestures were lip protrusion, mouth opening, tongue protrusion, and sequential finger movement. The infants' facial behaviors were video-recorded and subsequently scored by judges who remained uninformed as to the infants' stimulus conditions. The results showed that infants differentially imitated all four gestures.

Infants in this first study were allowed to respond while the display was presented. We next wondered whether early imitation might be constrained to some form of ''motor resonance'' or coaction that could easily be disrupted if a short delay was imposed between the modeling and response. To

investigate this, study 2 was conducted, using a new group of sixteen- to twenty-one-day-old infants. Again a repeated-measures design was used, in which each infant served as his/her own control. The target displays were mouth opening and tongue protrusion. We developed a pacifier technique in which the presentation of the visual stimulus and the infant's response were temporally split by providing infants with a pacifier to suck on during the visual displays. For example, the mouth-opening display was demonstrated while the infant was sucking on a pacifier. After the demonstration was complete, the experimenter assumed a passive-face pose and only then removed the pacifier. A 150-second response period was then timed, during which the adult maintained a passive facial pose. Immediately thereafter, the pacifier was reinserted, and the second gesture was presented in an identical manner. Order of gesture was counterbalanced across infants.

It is noteworthy that the infants actively sucked on the pacifier during the stimulus-presentation periods. They did not tend to open their mouths and let the pacifier drop out during the mouth display; nor did they tend to push the pacifier away with their tongues during the tongue display. The sucking reflex took precedence over any imitative tendency and ensured that infants engaged in competing motor activity during the presentation of the display (Meltzoff and Moore 1977, 1983b). Even with this pacifier technique, the findings supported the hypothesis of imitation. Taken together, the two 1977 experiments showed that very young human infants can generate matching responses to certain simple body movements presented by adult models.

How can we account for this unexpected infant competence? If pressed, an advocate of the primacy-of-social-mirroring perspective might argue that infants had learned to copy these displays during the mother-infant interactions that occur in the very first postnatal weeks, often surrounding feeding (Brazelton and Tronick 1980). The goal of the next study was to test this idea.

Social Modeling Effects in the Newborn

If early infant matching behavior depends upon prior social learning, then newborn infants should fail at these tasks. To address this question, we tested forty newborns with a mean age of thirty-two hours (Meltzoff and Moore 1983a). The youngest subject was only forty-two minutes old at the time of test.

The infants were tested in a laboratory located within a newborn nursery. Following the logic of the cross-target comparison, infants acted as their own controls. Each was presented with both a mouth-opening and a tongue-protrusion gesture in a repeated-measures design, counterbalanced for order of presentation. The experiment was videotaped and subsequently scored by an observer who was blind to the modeled behavior. The results showed that the infants matched the adult behaviors. There were significantly more infant mouth openings in response to the mouth display than to the tongue display

($z = 2.26$, $p < .05$, Wilcoxon matched-pairs signed-ranks test). Conversely, the frequency of infant tongue protrusions was greater to the tongue display than to the mouth display ($z = 3.31$, $p < .001$). Recently, these findings have been replicated and extended in another sample of forty infants less than seventy-two hours old (Meltzoff and Moore 1989). One of the gestures used in this new study was a nonoral gesture, head movement, thus demonstrating that the newborn matching phenomenon has some generality and is not restricted to tongue protrusion and mouth opening. We can conclude that extended postnatal learning from interactions with caretakers is not a necessary condition for imitation in humans. Some primitive capacity to copy the actions of adults appears to be present from birth.

What psychological mechanism could possibly underlie this behavior? I have written at length about several alternative models, ranging from the notion that it is a mindless response, to some sort of intentional copying (Meltzoff 1985b; Meltzoff, Kuhl, and Moore, in press; Meltzoff and Moore 1977, 1983a, 1983b, 1985, 1989). While recognizing that the available data invite alternative inferences, one hypothesis we developed bears mention here. This view holds that infants can, at some level of processing, apprehend the equivalences between body transformations they see and body transformations of their own that they proprioceptively "feel" themselves make. Infants see the adult's display and incorporate it as a kind of target against which they can compare their ongoing movement patterns and body postures. This immediately raises the problem of the coding of the adult's display. It could not be a purely iconic visual image of the behavior, because then there would still be the problem of how the infant links up the visual image of the other and the motor image of the self. Thus, we have proposed that the infant may encode the spatiotemporal events that constitute human actions in some sort of *supramodal* code, a non-modality-specific description of the human act. Such a representational code would be akin to the supramodal phonetic unit postulated by Kuhl and Meltzoff (1984, 1988) to encompass both the auditory and articulatory representations of speech in the preverbal child, which was necessitated by findings of vocal imitation and lipreading phenomena in very early infancy (Kuhl and Meltzoff 1982). The empirical and theoretical work by Bower (1977, 1982, 1989) and Gibson (1966, 1979) has led them to develop and elaborate very similar notions.

The idea of a supramodal representational system means, metaphorically, that the visual, motor, and possibly auditory systems "speak the same language" right from birth. There is not a gradual stitching together of initially independent spaces—a visual space, a buccal space, an auditory space—all of which are functionally independent and coordinated with growth and experience, à la Piaget (1954). Rather, information picked up by the separate sense organs could be represented within a "common space." This idea of a perceptual system that operates on supramodal information has not

been fully mined for its implications about the notion of self. It is, however, extremely relevant to the development of self, because it allows us to hypothesize that even during early infancy the "other," as picked up through one modality (such as vision), is represented in a code accessible to the self, as picked up through proprioception. Discussed next are the fuller implications of this view and a way it can be integrated with the findings from older infants, discussed previously.

Conclusions: Implications for Self, and Extensions to Understanding "Other Minds"

Three aspects of imitation—social mirroring, social modeling, and imitation as self practice—that may be particularly relevant to developing a theory of the self have been highlighted.

In the first, the adult acts as a kind of social mirror (analogous to a physical mirror) and reflects the infant's own behavior back to him/her. The infant's appreciation of social mirroring was demonstrated in a preprogrammed interaction in which an adult purposely imitated the infant. We compared the infant's reaction to this mirroring adult versus an adult whose behavior was also temporally contingent on the infant's but who consistently mismatched the infant's behavior. We found that infants preferred the adult who was actually imitating them; infants seemed able to recognize human acts that were structurally equivalent to their own. They looked and smiled more at the mirroring other. They also "tested" the adult, possibly checking where the identity between self and other broke down.

This social mirroring effect is not purely a laboratory phenomenon. The gestural dialogues between infants and their caretakers are well documented, and theorists have commented that infants seem to take pleasure in the temporal aspects of these early exchange games. The perspective added in this chapter is that infants may also take pleasure in the fact that in these episodes the adult's acts become more "like me" in their form. Social mirroring may be a primordial form of communication between adult and infant. It would be meaningful to both partners because both could recognize their common acts.

This would also help provide the infant with a growing sense of the self, because such exchanges are one natural way (in addition to physical mirrors) infants can discover what their acts look like. In these special interactions, the infants can, in a sense, see a reflection of themselves in the other (Lacan 1977; Winnicott 1967). This might enhance and solidify the infant's sense of causality and self-agency. Moreover, I would propose that social mirroring is a unique and important constituent of early enculturation, because a social mirror (unlike a physical mirror) is both *selective* and *interpretive* in its reflections. Parents, as social mirrors, provide "creative reflections" to their

infants, reflections that capture aspects of the infant's activity but then go on beyond it to read in intentions and goals to that behavior. The infant may wave an object, but the parent interprets this as waving in order to shake and therefore waves intensely enough to shake the toy and produce a sound, which in turn leads the infant beyond his or her initial starting point. Likewise, selected actions, especially those that are potentially meaningful in the culture, will be reflected back more often than others (Bruner 1975, 1983). What I am calling social mirroring is one aspect, an important one I believe, of the larger issue of parental teaching strategies and what Bruner and others have called parental "scaffolding."

Imitation is used not only by caretakers but by the infants themselves to mark salient events. This raises the hypothesis of imitation as "self practice," which was a further facet of imitation highlighted in this chapter. In one study, infants were tested for deferred imitation of a target with and without an opportunity for immediate, on-line imitation during the display itself. We found that infants given the opportunity for immediate imitation were superior imitators after a twenty-four–hour delay than were those treated identically but without the initial opportunity for immediate imitation. It appears that in imitating an act themselves, infants may confer it with a privileged or enriched status. It is intriguing to think there is a link between the infants' immediate imitative reactions, which are re-presentations to themselves in action, and their consolidation of internal representations and memories. The notion of imitation as self practice deserves further study.

The social modeling effects discussed here provide a productive measure of infants' appreciation of self-other correspondences (as opposed to the recognitory measures provided by either the social or physical mirror studies). Infants are posed a problem: An adult produces a novel behavior such as touching an orange panel with his forehead, and now the infant is faced with the same panel. Even assuming some motivation for duplication, should the infant use his foot, his hand, his tongue? What behavior of the infant's corresponds to the act he observed? By age fourteen months, infants have no difficulty accurately imitating the head-touch behavior after a one-week delay. Other studies used pure body actions, without objects, including a sample of newborns, the youngest of whom was forty-two minutes old at the time of test. The data show that even newborns will generate matching responses: they will poke out their tongues when they see that display and will switch to mouth opening/closing when they see that performed. The range of actions imitated by young infants is quite broad and, in addition to oral movements, includes hand movements (Meltzoff and Moore 1977) and even head movements (Meltzoff and Moore 1989). We concluded that some primitive form of imitation is literally natural to humans from birth.

The mechanisms underlying this early behavioral matching are under investigation in our laboratory and others'. But as a working model, we have

proposed that infants, even these newborns, are capable of apprehending the equivalence between body transformations they see and ones they feel themselves perform. According to this view, early matching behavior is a manifestation of an active intermodal mapping process. It may not be too much to suggest that the young infant possesses an embryonic "body scheme," including equivalences between body acts perceived and body acts performed. Of course, this body scheme develops—perhaps in part through social mirroring experiences and self practice of the type discussed earlier in this chapter. But my interpretation of the early imitation results is that some body-scheme kernel is present as a "psychological primitive" right from the earliest phases of infancy. This nascent notion of self is a foundation from which self development proceeds, not an endpoint that is reached after months or years of interactions with the social environment.

How Imitation May Contribute to the Infant's Grasp of "Other Minds" and Emotions

Interviews with parents in my laboratory suggest that they enjoy playing mutual imitative games with their infants because this accentuates for them that their infant is, like them, a sentient human being. Evidently, this is an attribution that comes easily when there is successful nonverbal communication, even for a fleeting moment, between the parent and infant. However scientifically uncontrolled and epistemologically naive these parental opinions may be, that is what the parents experience—that is what is going on in their hearts and minds. It appears to be a natural psychological attribution.

The point I will make here is that such imitative episodes may serve to raise this "sentience" issue for the naive infant as well as for the adult. In other words, just as parents base their inference of infant sentience on communicative encounters with their child, this "natural psychological attribution" may also be operative in infants and form a basis for them to make inferences about the sentience of the adults. At what point in development and by what mechanism does the infant see the adult as an "other mind" with intentions, thoughts, and emotions (Astington, et al. 1988; Perner, in press; Wellman, in press)? One hypothesis would fix the beginning of this development at the age at which children begin to use "internal state" words (e.g., happy, sad) as descriptors (e.g., Bretherton and Beeghly 1982). The data reported here, however, suggest that infants may have the tools to make some initial headway on this problem before these first verbalizations, in part through early imitation and the capacities that underlie it.

To clarify the relevance of the work on imitation to the problem of "other minds," I will focus on one example involving the earliest understanding and attribution of emotion to other human beings. Ekman's findings (Ekman 1984; Ekman, Levenson, and Friesen 1983) suggest that there is a basic connection

between certain emotional states and their manifestations in facial expression. If so, infants could, in principle, come to detect the conjunction in themselves between the facial movements they feel themselves make and these underlying states. Assuming that infants detect these regularities in themselves, could this experience help them ''read'' the faces of others? Unfortunately, it would be of no use to young infants if there were no way for them to bridge from themselves to others. Indeed, that is the situation they are left in, according to orthodox developmental theory.

However, the new findings of early facial imitation become very relevant here. This work demonstrates precisely and quite strongly that infants can relate the gestures they see on another's face to their own unseen facial behavior. The fact that infants imitate the expressions they see suggests that they can detect similarities, *at least at a behavioral level*, between the actions of the self and the other (Meltzoff 1985b; Meltzoff and Moore 1985, 1989). This detection of the similarity could be pivotal in developing a theory of mind that includes the other as a sentient being, for it would provide infants a way of giving subjective meaning to the emotional expressions they see in others. Inasmuch as infants perceive regularities between their own expressions and emotional states (à la Ekman) and also perceive similarities between others' unseen expressions and their own (à la our work on facial imitation), they would have the information necessary to appreciate that the other has emotional states similar to their own. The line of reasoning involves the following three steps:

1. When I am in a certain emotional state, my face makes a certain behavioral expression (the facial behavior–emotional state link reported by Ekman).

2. I can recognize that the behavioral expression in another is similar to the one I make (the visual-proprioceptive link reported by Meltzoff and Moore).

3. If the other is producing the same behavior I produce when experiencing a certain emotional state, then perhaps the other is experiencing that emotion (the emotion that goes with that behavior in me).

The suggestion is that the foregoing process infuses the expressions seen in others with meaning from personal experience. The hypothesized three-step process could also be applied to recognizing ''intentionality'' and ''desires'' in the other, as well as to a host of issues related to the psychogenesis of other minds. Baldwin (1906), Mead (1934), and other psychologists and philosophers have long explored these problems. The three new empirical elements that can now be brought to bear on the problem of other minds are (*a*) Ekman's findings, (*b*) Meltzoff and Moore's data that young infants can match the behaviors of others, and (*c*) the fundamental theoretical notion that cross-modal links between the seen and the unseen (the other's face and one's own) can be apprehended very early in life. I believe these three factors contribute to the development of the notion of self and to an infant's

impression of the psychologically sentient other. Imitation lies at the cross-roads of infants' elaborating a concept of self and expanding their understanding of the minds and emotions of others.

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