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CHAPTER TWO

Social Cognition and the Origins of Imitation, Empathy, and Theory of Mind

Andrew N. Meltzoff

Scientists interested in social cognition investigate people's beliefs about thinking, feeling, and perceiving. This is differentiable from our knowledge of the physical world and logical-mathematical principles. Social cognition has deep roots in psychology (Heider, 1958), but was under-investigated by Piaget and Vygotsky. Piaget's *The Construction of Reality in the Child* contains brilliant chapters on objects, space, time, and causality. There are, however, none on people. His *Play Dreams and Imitation in Childhood* discusses people, but not how children come to understand the inner life of others. Even Vygotsky, whose *Mind in Society* highlights social interaction, does not focus on how children come to see others are thinking, feeling, and wanting beings.

Defining the Problem of Developing Social Cognition

What is the central problem of social cognition and why does it intrigue modern developmental theorists? The problem stems from the fact that persons are more than physical objects. When we describe a person's height, weight, and eye color, we do not exhaust

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Correspondence concerning this article should be addressed to Andrew N. Meltzoff, Institute for Learning and Brain Sciences, Box 357920, University of Washington, Seattle, WA 98195. Phone: 206-685-2045, fax: 206-221-6475, email: meltzoff@u.washington.edu.

our description of that person. We have omitted the individual's psychological makeup. If a self-mobile agent was devoid of psychological characteristics, we would not consider it a person but a robot, or to use a philosopher's favorite term, a zombie. A fundamental issue is how we come to know others as psychological agents like ourselves.

Each one of us has the phenomenological experience that he or she is not alone in the world, not the unique bearer of psychological properties. We know that we think, feel, and have intentions. We also find ourselves believing that others have similar psychological states, despite the fact that we do not experience others' states in the same way that we experience our own. Reflection on this gulf between self and other intrigues us. A robot with voice synthesis might cry out when pinched, but it does not feel pain. It can be programmed to wrinkle its elastic "brow" when its speech-recognition chip detects human sobbing, but we would not ascribe it empathy. Why, then, do we attribute psychological states to other humans?

Philosophers seek to justify the intuition that the sacks of skin we see around us are animated by psychological states like our own. Philosophers contemplate whether this is true and the criteria for knowing whether it is or is not – the problem of Other Minds (e.g., Campbell, 1994; Ryle, 1949; Strawson, 1959). This philosophical conundrum remains unsettled. Yet adults talk, act, and write in the hope of touching the minds and feelings of others. By 2–4 years of age all typically developing children treat others as intentional agents – having developed a practical solution to the problem of Other Minds. How does such a view take hold in children, whether it is justified or not?

Classical Theories of Childhood: The "Impossible Journey"

Classical theorists, including Freud, Piaget, and Skinner, all agree on one axiom: newborn infants have no inkling of the similarity between self and other. A primary task of psychosocial development is to build connections to others, so that the child realizes he is "one of us." The progression is from newborn solipsist to social intimate.

This is, I would argue, an impossible journey. But it was central in the classic literature. Freud and his followers proposed a distinction between a physical and psychological birth. When the baby is born there is a physical birth but not yet a birth of a social mind (Freud, 1911; Mahler, Pine, & Bergman, 1975). The baby is like an unhatched chick within an eggshell, incapable of interacting as a social being because a "barrier" leaves the newborn cut off from external reality:

> A neat example of a psychical system shut off from the stimuli of the external world … is afforded by a bird's egg with its food supply enclosed in its shell; for it, the care provided by its mother is limited to the provision of warmth. (Freud, 1911, p. 220)

This view deeply influenced psychiatry (Beebe, Knoblauch, Rustin, & Sorter, 2005; Beebe, Sorter, Rustin, & Knoblauch, 2003) and led psychoanalysts to postulate an early period of "normal autism" (Mahler et al., 1975, p. 42), which was only escaped via appropriate mothering.

Piaget's newborn is similar, but he drew on a philosophical metaphor. He believed that the baby is "radically egocentric" or "solipsistic" (Piaget, 1954, pp. 352–357). The neonate has only a few reflexes at his or her disposal (sucking, grasping), and other people are registered only inasmuch as they are assimilated to these action schemes:

> During the earliest stages the child perceives things like a solipsist … This primitive relation between subject and object is a relation of undifferentiation … when no distinction is made between the self and the non-self. (Piaget, 1954, p. 355)

The infant breaks free of solipsism by 18 months through cognitive development.

Skinner (1953) gave his blank-slate infant even less to work with. One cannot quote from Skinner about how children crack the puzzle of social cognition, because he does not think they ever do. To use Skinner's phrase, social cognition is largely a "matter of consequences" (Skinner, 1983) – we never really know others' minds, only their external behavioral reactions to us.

Two Types of Nativism

Modern research in developmental science changed these ideas. We now know that there is a much richer innate state than posited by Freud, Piaget, and Skinner. The nativists won the battle over the newborn's mind, but two distinct schools of nativism have emerged. The distinction is especially pronounced regarding social cognition. One view, *starting-state nativism*, argues for a rich innate state that undergoes conceptual change starting at birth, well before the influence of language (e.g., Gopnik & Meltzoff, 1997; Meltzoff & Moore, 1998). The other, *final-state nativism*, argues that the initial state is equivalent to the final state or is slightly enriched without qualitative transformations of the essential core knowledge (e.g., Spelke, Breinlinger, Macomber, & Jacobson, 1992). As a final-state nativist, Fodor believes that adult social cognition is innately specified:

> Here is what I would have done if I had been faced with this problem in designing *Homo sapiens*. I would have made a knowledge of commonsense *Homo sapiens* psychology innate; that way nobody would have to spend time learning it … The empirical evidence that God did it the way I would have isn't, in fact, unimpressive. (Fodor, 1987, p. 132)

Fodor thinks the newborn innately possesses the mature theory of mind (see also Onishi & Baillargeon, 2005). Moreover, he says there are no alternatives: "I take the lack of a rival hypothesis … to be a kind of empirical evidence" (Fodor, 1987, p. 132).

One of the goals of this chapter is to fill Fodor's gap and provide a rival hypothesis. In the starting-state view, infants have innate abstract knowledge, but the newborn does not innately possess the adult model. Evolution has provided newborns with powerful "discovery procedures," and genuine conceptual change starts in the prelinguistic period. The view is not standard Piaget, because the psychological primitives infants use to interpret their first encounters with people are different. Instead of Piaget's reflexes and action schemes, infants have abstract psychological structures that allow them to interpret others as "like me." This fundamental identification with others provides a toehold for developing social cognition.

The "Like-Me" Theory: Developing Social Cognition

Piagetian solipsism, Freudian eggs, and Skinner's contingencies will not get us from the newborn to the adult state because there is not enough innate structure to make use of the experience in social interaction. But this does not mean that the mature adult state is built in. Surely there is room for development, and the project is to specify the innate primitives and a plausible engine for social-cognitive change.

The Like-Me theory proposes three developmental phases for getting early social cognition off the ground (figure 2.1). It describes the infant's initial state (Developmental Phase 1) and also a process of change (phases 2 and 3). The older child and adult are not locked into the same understanding as the newborn.

Developmental Phase 1: starting state

The first phase is functional at birth. It concerns the representation of action. Newborn imitation provides evidence of an intrinsic link between the perception and production of human acts. When newborns see adult behavior, these acts are mapped onto the infant's body movements. Self and other are connected through an abstract representation of human acts, which we call a *supramodal representation* (Meltzoff & Moore, 1977, 1997), because it cuts across modalities. It is because of the infant's action representation – the supramodal code – that the movements of people are special to young babies. The child, even the newborn, processes the movements of other people and recognizes: "that looks the way this feels" or "those acts are like these acts." The fact that others are seen as "like me" provides an interpretive lens for infants' first social encounters. It is not learned, but provides the groundwork for learning, especially about people.

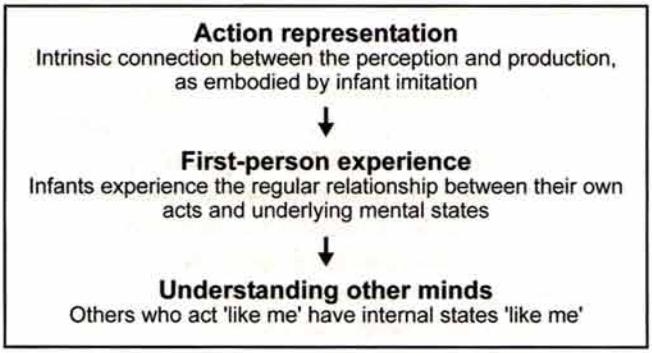

Figure 2.1 "Like-Me" theory for early social cognition (From Meltzoff, 2007b.)

Developmental Phase 2: first-person experience

The second phase is based on individual experience and provides an engine for developmental change. Through everyday experience infants map the relation between their own bodily states and mental experiences. For example, there is an intimate relation between striving to achieve a goal and the concomitant facial expression and effortful bodily acts. Infants experience their own unfulfilled desires and the simultaneous facial/postural behavior. From these experiences, they develop a detailed bidirectional map linking internal states and behavior (Meltzoff & Moore, 1997).

Developmental Phase 3: attributions to others

The third phase involves attribution. When infants see others acting similarly to how they have acted in the past – acting "like me" – they make an attribution. They ascribe the internal feelings that regularly go with those behaviors, based on their self-experience. This gives infants leverage for grasping other minds before language can be used. Infants' first-person experience could not be used in this way if they did not perceive the equivalence between their own acts and those of others (Phase 1, as indicated by imitation). Nor would it get very far if there was no systematic link between their own internal states and bodily acts (Phase 2). Humans, including preverbal infants, imbue the acts of others with felt meaning because the other is processed as "like me."

This attributes a good deal of machinery to infants, but it is not Fodorian (1987) nativism. Newborns do not have the adult theory of mind preloaded in their mind. The remainder of this chapter fleshes out this idea by showing how infants use the concept of "like me" in their social interactions.

Conceptual distinctions and caveats

Bidirectionality. Although the view proposed here is dubbed "Like Me," this is a shorthand, because the supramodal code supports *bidirectional* learning effects. Going in the direction of the inside out, infants' understanding of others' acts is enriched by performing similar acts themselves. Going from the outside in, infants learn about themselves and the consequences of their own potential actions by observing the acts of others (Meltzoff, 2007b). The result is a child who discovers facets of other minds through comparisons with his or her own mind and who simultaneously discovers powers and possibilities of the self through observing and imitating others (for example, infants learn novel acts from watching others, Meltzoff, 1988). The Like-Me framework suggests that the same underlying mechanism supports learning in both directions. Experiments in our laboratory have demonstrated this bidirectionality (Meltzoff, 1988, 2007a, 2007b; Repacholi, Meltzoff, & Olsen, 2008; Williamson, Jaswal, & Meltzoff, in press; Williamson, Meltzoff, & Markman 2008).

Theoretical terms. When writing about infants, English words are problematic. The words call up adult meanings, and infant concepts are not the same as adults'. The use of the words "me" and "self" in the Like-Me framework are not meant to imply that infants adopt the adult meanings. The "me" of the adult entails verbal self-reflection. It also involves appearances (what I see in the mirror) and moral values (I am a generous person). When I say that the infant construes another as "like me," what I mean is that the infant recognizes a cross-modal equivalence between acts that they observe in others and acts that they produce themselves: "That seen act is like this felt act." I am not appealing to a mature sense of "me" or "self," which I assume to be a developmental achievement.

Further development. The Like-Me framework provides only a partial story about how we come to understand others as intentional agents in the mature adult manner. The mental states most amenable to this analysis are desires, perceptions, emotions, and simple intentions. For these, there is a relatively close coupling between the internal mental states and their outward expression in bodily actions. When someone *sees* x or *desires* y, there are concomitant bodily movements (looking in the direction of, leaning towards, grasping, etc.). These bodily movements are observed in others, and they are produced by the self.

Other mental states have fewer behavioral markers. The "*belief* that x" can be held in the absence of telltale action. Although a person cannot visually inspect an object without bodily movements or become white-hot angry without behavioral leakage, he can certainly conjure up a belief while sitting stock-still. Moreover, people can silently hold beliefs that *conflict* with my own, for example, false beliefs (e.g., Astington & Gopnik, 1991; Flavell, 1999; Perner, 1991; Wellman, 1990; Wellman, chapter 10, this volume). The Like-Me framework provides the initial foothold for interpreting others as bearers of psychological properties *commensurate* with one's own, but further development is needed for acquiring the mature theory of mind encompassing beliefs that directly *conflict with/contradict* one's own.

Action measures. Infants may know more than they produce. This chapter focuses on infants' motor production for three reasons. First, there are comprehensive reviews of infants' parsing of human action based on looking-time response measures that do not require them to take action (Csibra, 2003; Csibra & Gergely, 2007; Gergely, chapter 3, this volume; Johnson, 2000, 2003; Sommerville & Woodward, 2005; Woodward, 2009). Second, infant action measures are important for developmental theory. The feedback infants receive from the social world is largely based on what they do (Rochat, 2009), not on what they do not express. Third, the transfer of goals and intentions from one actor to the next – the ability to carry out someone else's intentions – is crucial for seamless communication and interpersonal rapport.

Imitation and the Early Phases of Social Cognition

Starting-state nativists seek the origins of social cognition in the abstract representation of action available to human newborns – the supramodal code. The data from early imitation is well suited for exploring this perception–production expressway starting from the earliest stages of infancy. Imitation demonstrates that, at some level of processing, infants use the perceived behavior of others as a basis for producing similar behavior. Through imitation, infants make manifest a basic connection between self and other.

Meltzoff and Moore (1977) reported that 12- to 21-day-old infants imitate facial expressions. Subsequent studies revealed newborn imitation in a hospital setting (Meltzoff & Moore, 1983, 1989). The youngest infant was only 42 minutes old. Because of the theoretical tradition of Piaget, Freud, and Skinner, early imitation was at first considered surprising to developmental theorists, but it has now been replicated in 25 studies from 13 independent laboratories around the world. (For a review see Meltzoff & Moore, 1997). Today it is not as surprising that the perception and production of human acts are closely connected at birth.

Theoretical accounts of early imitation need to encompass three facts:

1. *Infant imitation entails specific matching, not global arousal.* The data demonstrate that imitative reactions are not a general arousal reaction. Rather infants' responses vary as a function of the act shown. Early imitative matching is specific in terms of both the *body part* used and the *action* evoked. Meltzoff and Moore (1977) found that infants move the same body part in different ways when they are shown two different actions with it (mouth opening versus lip protrusion). They also use two different body parts to produce the same movement (protrusion of the lips versus protrusion of the tongue). Infants even differentiate different types of tongue protrusions: straight tongue protrusion versus tongue out to the side of the mouth (Meltzoff & Moore, 1994, 1997). Such response specificity cannot be accounted for by general arousal. We need a theory that encompasses such specific mapping.

2. *Infants show temporal flexibility, not immediate mimicry.* The imitative response can be displaced in time and space from the demonstration. In one study, a pacifier was put in neonates' mouths as they watched the display. The adult then assumed a passive-face pose and removed the pacifier. Infants imitated the now-absent display based on memory (Meltzoff & Moore, 1977). In another study, 6-week-old infants were shown a gesture, and then left the laboratory for a 24-hour memory delay. The next day they were presented with the same adult sitting with a neutral facial expression. If the adult had shown mouth opening the day before, the infants initiated that gesture; if the adult had shown tongue protrusion, infants responded with that gesture (Meltzoff & Moore, 1994). Infants are not limited to duplicating the perceptual stimulus that is in front of them. Infants can imitate based on their stored representation of absent social stimuli.

3. *Infants correct their imitative efforts.* Early imitation is not rigidly fixed or stereotypic. From birth, infants correct their imitative attempts so that they more and more closely converge on the model demonstrated (Heimann, Nelson, & Schaller, 1989; Kugiumutzakis, 1998; Maratos, 1982; Meltzoff & Moore, 1983, 1994, 1997). For example, if the adult shows a novel gesture such as a tongue-protrusion-to-the-side-of-the-mouth, infants will begin with ordinary tongue protrusions before beginning to move it to the side. They use the proprioceptive feedback from their own actions as the basis for guiding their response to the target (Meltzoff & Moore, 1994, 1997). This is genuine imitation.

A Theoretical Model of Imitation: Connecting Self and Other

Meltzoff & Moore (1997) offered a theoretical model of the mechanism underlying imitation. We believe that imitation depends on a process of active intermodal mapping (AIM). The crux of the AIM hypothesis is that imitation, even early imitation, is a matching-to-target process. The goal or behavioral target is specified visually. Infants' self-produced movements provide proprioceptive feedback that can be compared to the visually specified target. AIM proposes that such comparison is possible because both perceived and performed human acts are represented within a common supramodal framework (figure 2.2).

Our account also specifies the metric of equivalence used by infants. The key insight is that an imitative act is not one indissociable unit. It can be differentiated into the *body part* used and the *movement* performed.

Organ identification

Regarding the former, the evidence suggests that neonates isolate what body part to use before determining how to move it. For example, when they see tongue protrusion, there is often a quieting of the movement of other body parts and an activation of the tongue. Infants don't necessarily protrude the tongue during this initial phase, but may elevate it or move it slightly in the oral cavity. The important point is that the tongue, rather than

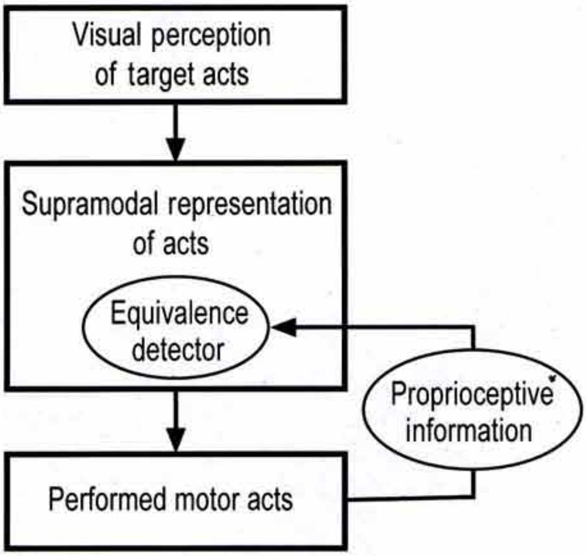

Figure 2.2 The AIM mechanism of imitation. According to AIM, imitation is a matching-to-target process. The imitator can correct errors by using proprioceptive feedback to compare their own actions to a visually specified target (From Meltzoff & Moore, 1997.)

the lips or fingers, is energized before the movement is isolated. We call this *organ identification*.

Neuroscience data show that visual displays of parts of the face and hands activate specific brain sites in monkeys (Desimone, 1991; Gross & Sergent, 1992; Jellema, Baker, Oram, & Perrett, 2002; Rolls, 1992) and humans (Buccino et al., 2001). These brain findings fit with the fast activation of a matching body part by neonates. Specific body parts could be neurally represented.

Body babbling and self-experience

Regarding the movement component, we don't think it is innately specified as to which muscle movements yield which particular body configurations. This could be the result of motor experience gained during motor play. Infants freely move their bodies including producing lip and tongue movements, both postnatally and also prenatally (Hooker, 1952; Patrick, Campbell, Carmichael, Natale, & Richardson, 1982; de Vries, Visser, & Prechtl, 1982; de Vries, Visser, & Prechtl, 1985). We call such self-generated motor experience *body babbling* (Meltzoff & Moore, 1997). Through body babbling, infants acquire a rich store of information about how their bodies work and the consequences of their muscle movements.

Body babbling provides experience linking muscle movements to resulting body configurations. Infants can appreciate the equivalence between the seen "tongue-to-lips" (an *organ relation*) and their own felt "tongue-to-lips," because they express the same arrangement of body parts. When they see such a body configuration they recognize what muscles to activate to achieve it, because they have learned how to reach that end state through previous body babbling. In this sense, body babbling works analogously to vocal play/babbling, which serves to link articulatory acts to auditory targets and supports vocal imitation (Kuhl & Meltzoff, 1982, 1996). In both the vocal and the action case, infants' prior motor experience – including *in utero* motor experience in the case of facial imitation – may play a crucial role in preparing them for later imitation. The AIM theoretical model is fleshed out in more detail in Meltzoff and Moore (1997).

Evidence from Neuroscience: Perception–Production Mappings and Mirror Neuron Systems

The idea of a supramodal representation of action that we used to explain behavioral imitation 30 years ago fits well with modern neuroscience discoveries. Neuroscientists have documented a striking overlap in the brain systems recruited for the perception and for the production of actions (e.g., Hari & Kujala, 2009). In a neuroscience study related to facial imitation, researchers showed adults articulatory movements and found neuronal activation in the cortical areas responsible for producing those articulations (Möttönen, Järveläinen, Sams, & Hari, 2004).

One crucial task for the future is to analyze the commonalities and the differences between the supramodal code, which is proposed at the psychological/personal level, and shared neural circuits, which encode activity at the sub-personal level. Analyses are beginning to emerge (e.g., Gallese, 2003; Hommel, Müsseler, Aschersleben, & Prinz, 2001; Iacoboni, 2005; Jackson, Meltzoff, & Decety, 2006; Meltzoff & Decety, 2003; Rizzolatti, Fogassi, & Gallese, 2001).

A second need is for *developmental* social-cognitive neuroscience studies to explore the neural machinery underlying infant perception–action links (Lepage & Théoret, 2007; Nyström, 2008). We know from the behavioral work on imitation that links exist, and this can help guide the neuroscience work. This is technically challenging work, however, because functional MRI is not suitable for newborns and EEG does not provide good localization data. The application of magnetoencephalography (MEG) technology to infants may provide a way past this roadblock. A MEG study traced changes in the neural network linking perception and production for speech stimuli in newborns, 6-month-olds, and 12-month-olds (Imada et al., 2006). The results at 6 months of age showed that listening to speech activates Broca's area, which controls speech production, although listening to non-speech sounds does not. Because MEG technology tolerates infant movements and provides excellent spatial and temporal resolution, it promises to be an ideal tool for studying perception–production couplings from infancy to adulthood.

Another area for needed work concerns animal studies from a developmental perspective. Despite a plethora of papers on mirror neurons in monkeys (Gallese, Fadiga, Fogassi & Rizzolatti, 1996; Rizzolatti & Craighero, 2004; Gallese, Fadiga, Fogassi, Rizzolatti, 1996), we currently lack the crucial *developmental* studies with newborn animals. Adult monkeys have repeatedly watched themselves grasp objects. The mirror neurons so far reported in adult monkeys could be formed based on such learning experiences. Developmental animal studies are needed to assure that we do not over-interpret the studies (for caveats about over-interpreting mirror neurons, see Hickok, 2009; Molenberghs, Cunnington, & Mattingley, 2009; Saxe, Carey, & Kanwisher, 2004).

Person Identity: Social-Communicative Functions of Imitation

We have seen that young infants recognize the similarity between self and other, which serves as a toehold for building social cognition. Nonetheless, there are some elementary aspects of social cognition that neonates don't grasp. One of the most surprising concerns the understanding of the identity of people. Keeping track of individuals is fundamental to adult social cognition. Social relations are not an oceanic feeling of connectedness with an undifferentiated universe of others. Adult social cognition involves specific others valued for their individuality.

In developmental science the complexities of tracing an individual's identity over time and space are usually discussed in relation to inanimate objects (Moore & Meltzoff, 2009; Spelke, Kestenbaum, Simons, & Wein, 1995; Xu & Carey, 1996). However, the same issues arise with people. People come and go: How do I know that this is the same person again – the same individual with whom I have a relationship?

In considering the role of identity in social cognition it is crucial to distinguish two meanings of identity or "sameness." One meaning is that of an entity being the self-same individual over different encounters in space and time. This is called "numerical identity." A different meaning of sameness concerns appearances. This is referred to as "qualitative" or "featural" identity. My can of Pepsi and yours differ in numerical identity but share the same qualitative or featural identity. Investigations of object permanence are concerned with numerical identity (Meltzoff & Moore, 1998; Moore & Meltzoff, 2004, 2008) – whether infants interpret the reappearing object as the same individual one that had disappeared; investigations of categorization are chiefly concerned with qualitative identity – "Is this exemplar the same kind as the other?" (Quinn, 2002).

Attachment and romantic love depend on distinguishing numerical and qualitative person identity. One stays in love with one's wife despite her new hairdo (same individual, different appearance). Each husband loves his own wife, even if she has an identical twin (same appearance, different individual). How do infants individuate one person from another and re-identify a person as the "same one" again after a break in perceptual contact? This can be posed as a baby-sized problem.

Infants use imitation to determine a person's identity

In one study, we presented 6-week-old infants with people who were coming and going in front of them, as would happen in real-world interaction (Meltzoff & Moore, 1992). The mother appeared and showed one gesture (say, mouth opening). Then she exited and was replaced by a stranger who showed a different gesture (say, tongue protrusion).

When infants visually tracked these people exchanges they imitated each person in turn. But we also discovered an interesting error. If the mother and stranger surreptitiously changed places without the infant visually tracking the movements, infants did not differentially imitate. Instead, infants stared at the new person ... paused ... and then intently produced the *previous* person's gesture. In the absence of clear spatio-temporal evidence of twoness (visual tracking of the entrances and exits), infants were faced with an ambiguity: Is it the same person with a different appearance, or a new person in the old place? Infants used action imitation to help address this question.

Meltzoff and Moore postulated that when infants are uncertain about person identity, they are motivated to test whether this person has the same behavioral properties as the old one – whether she acts the same – because body-actions and expressive behavior of people are identifiers of who they are. For young infants, actions serve a *social identity function*.

Much as infants shake a familiar rattle to see if it makes the same sound, infants probe an adult's distinctive actions to test whether this is the same person again. "Are you the same person I saw before? Are you the one who does x? Is this the game we played together?" Empirical work shows that we can motivate infant imitation by posing baby-sized problems of personal identity (Meltzoff & Moore, 1992, 1994). Thus one of the functions of imitation is social-communicative. Imitation is used as part of identifying specific others and testing their personal identity (Meltzoff & Moore, 1995, 1998).

Mutual Imitation Games Develop Social Cognition

Mutual imitation exchanges serve an interesting adaptive function. Both social psychologists (Bargh & Chartrand, 1999; van Baaren, Holland, Steenaert, & van Knippenberg, 2003) and psychotherapists (Ogden, 1982; Racker, 1968) note that being imitated has positive value – people feel comforted, liked, and an increased sense of rapport when others reflect their behavior back to them.

Mutual imitation has also been studied within the developmental literature (e.g., Nadel, 2002), but the chief focus has been on the temporal, turn-taking aspect of such games (Beebe et al., 2005; Brazelton & Tronick, 1980; Bruner, 1975, 1983; Stern, 1985; Trevarthen, 1979). I don't dispute that timing and contingencies are important to infants, but think that the special power of mutual imitation lies in the equivalence of the *form* of the participants' behavior. Physical objects may come under temporal control. Only people, indeed only people who are paying attention to you and acting intentionally, can systematically match the form of your behavior in a generative fashion. Mutual imitation games are emotionally engaging for infants (and adults), because the other is perceived to be acting "like me."

Value of being imitated

I designed a series of studies to test whether infants could recognize being imitated, and the emotional value they placed on it. In one study, 14-month-old infants sat across a table from two adults. There were two TV monitors behind the infant, one displaying the actions of the current infant, live, and the other displaying a video record of a previous infant. One adult imitated the actions of the current infant and the other adult imitated the previous infant (yoked-control procedure). The results showed that infants looked longer at the adult who was imitating them and also smiled more often at that person (Meltzoff, 2007a).

Timing versus form. Infants could have preferred the imitating adult based on either of two cues. First, they could have used *temporal* contingency information. According to this alternative, infants need only detect that when they do an action the adult responds. Infants need not recognize that the two acts are structurally congruent. The second alternative is that infants can recognize that the acts share the same *form*. According to this alternative, infants recognize that the adult is acting "just like me," not "just when I act."

In another study, the purely temporal aspects of the contingency were controlled by having both experimenters act at the same time (Meltzoff, 2007a). Both experimenters sat passively until the infant performed one of the target actions on a preset list. When the infant did one of these target actions, it launched both experimenters in unison, but one of the adults matched the infant and the other performed a mismatching response. Even under these conditions infants looked longer and smiled more at the adult who was imitating them. This shows that infants can recognize when another acts "like me."

Social hypothesis testing. There is also an interesting constellation of behaviors I call "testing behavior." Infants modulated their acts by performing sudden and unexpected movements while staring at the imitator, as if to check whether the adult was intentionally copying them. For example, the infant might look at the adult and then slowly slide the toy across the table, and then, very suddenly, go faster and faster, as if to check if the experimenter is shadowing. Or the infant might suddenly freeze and look specifically at the imitating adult to see if he also freezes. Infants directed significantly more of this testing behavior to the imitating adult. This goes beyond simple resonance and mirror neuron activity, because the infant is purposely acting *differently* from what they observe.

Generative matching games. We found this pattern of looking, smiling, and testing behavior very strongly exhibited at 14 months of age (and more weakly at ages down to about 9 months of age). However, this is not an innate reaction. We set up studies for 6-week-olds in which an adult matched the infant's mouth opening and closing. The baby's attention was attracted, but it did not lead the baby to systematically switch to tongue protrusion or another gesture. There was no testing. Young infants process specific behavior-to-behavior mapping, whereas the older infants go beyond this and treat the interaction as a generative matching game. Older infants abstract the notion that the game is "you will do what I do" with substitutable behaviors. It is no longer simply a behavior-to-behavior link as per the neonate, but a more abstract notion of "matching game" generalized across particular instances.

Mechanism for change in understanding other minds

There are two developmental consequences of reciprocal imitation games. First, in such biological mirroring, infants gain a sense of what his or her acts *look* like, because they are shown by the other. There are aspects of self that can only be known by seeing reflections of yourself as others see you. This is an advance, because early imitation is mediated by supramodal equivalence in which modality-specific information is not preserved. Neonates can successfully imitate without knowing what their acts *look* like in a purely visual sense, from the outside looking in. Classical developmental theory supposed that mirrors promote such development. However, not all cultures throughout history used mirrors. Being copied by caretakers and peers in mutual imitative games is a more culturally universal mechanism for coming to understand what one looks like from another's perspective.

Second, imitation games provide occasions for infants to go beyond surface behaviors to the *intentions* that generate behavior. Consider the information embedded in the interaction. At first, infants perform their own actions without concern for their effects on the adult (because they don't know they're in a mutual imitation encounter). When the infants notice the adult movement, they shift their attention and begin to vary their own behavior. If the adult continues to match, infants produce novel testing probes and smile as the adult follows suit. This interactive game carries four vital pieces of information: (a) the adult's behavior matches the infant's; (b) it is not a random congruence but is systematic; (c) the specific behaviors don't matter, because the invariant in this situation is "to match"; and (d) from the infant's viewpoint, the infant's own novel behaviors were intended acts.

This provides information for promoting change: "I intend my acts; the other systematically performs matching acts; perhaps the other also intends his or her acts." This inference would expand interpersonal understanding beyond the neonates'. Thus reciprocal imitation games are a tutorial in seeing self and other as producers of intended acts, instead of merely equivalent surface behaviors. Repetitive experiences with mutual imitation games help infants achieve Phase 3 in the Like-Me framework (figure 2.1), in which they make attributions about the internal states of others based on the behaviors they see.

Neuroscience evidence on mutual imitation. From a neuroscience point of view, mutual imitation games pose an interesting issue about *agency* and the ownership of action. When a person is being imitated, a very special event occurs. There is one intended action, but the action is performed twice over – by the self and also by the other. Neuroscience work has begun to examine mutual imitation and discovered that the right inferior parietal region is activated when a person is imitated by another (Decety, Chaminade, Grèzes, & Meltzoff, 2002). This makes sense because this region is known to be involved in determining the agency and authorship of action (Decety & Chaminade, 2005; Farrer & Frith, 2002).

We hypothesize that in mutual imitation the right inferior parietal lobe is activated, because it is involved in differentiating actions produced by the self from similar actions produced by others. More speculatively, mutual imitation games are providing children with input about self–other correspondences but also about *differentiating* self from other. That is what the infant "testing" behavior is all about. The other is "like me" but is *not* me. Others do not do everything I do exactly when I will it – they merely shadow me.

Primitive Perspective-Taking: Infant Gaze Following

Neonates enjoy something like a social Garden of Eden – populated by self and other paying attention to and imitating each other. But this Eden soon ends. The child becomes aware that their caretakers sometimes attend to third parties, inanimate objects. We are surrounded by objects, and many of our thoughts and wants are directed toward them. The Like-Me framework is useful for explaining how infants come to interpret behaviors as being about something beyond the motor movements themselves, as object-directed or referential.

Consider the case of visual perception. When others turn to look at an object we realize that they can pick up information about it from afar, despite the spatial gap between viewer and object. We ascribe intentionality to the gazer who turns his head. Do infants understand this body movement in the same way? Or are head turns interpreted as nothing more than physical motions with no notion that they are *directed toward* the external object – no referential value?

This is a key theoretical issue, much debated in the literature (Carpenter, Nagell, & Tomasello, 1998; Flom, Lee, & Muir, 2007; Moore, 2006; Tomasello, Carpenter, Call, Behne, & Moll, 2005). One view is that adult looking behavior initially has no special value for young infants. In the leanest version, young infants simply are attracted by the salience of the adult's head movements. As the infant visually tracks the adult's head movement they are pulled to the correct hemifield where they accidently catch sight of the visual target object (Butterworth & Jarrett, 1991). Over time, infants then learn that the adult's head turn is a reliable cue indicating where an object can be seen (Moore, 1999, 2006). Conversely, Baron-Cohen (1995) offered a nativist view suggesting that infants have a built-in module that takes eye gaze as input and automatically makes attributions about seeing and visual experience in others. A third view is that infants' understanding of others' vision emerges developmentally. Meltzoff & Brooks (2008) propose that a mechanism of change is infants' experience with *their own vision*: infants develop an understanding of the vision of others, in part through their own acts of turning-in-order-to-see and opening/shutting of their eyes to cut off and reinstate visual experience.

Understanding eye closure as blocking perception

Crucial for sorting out the competing theories is determining whether infants are, as the lean view suggests, simply processing the salient physical movements in space caused by the head. Brooks and Meltzoff (2002, 2005) zeroed in on the importance of eyes in infant gaze following. The experimental manipulation was that the adult turned to the target with eyes *open* for one group and with eyes *closed* for the other group. If infants relied simply on head motions, as predicted by the lean view, they should turn in both cases. It is a step forward in social cognition for infants to put special emphasis on eyes as the organ of visual perception (something children with autism may not do; see Mundy & Newell, 2007), not only because this is necessary for understanding visual perception but also because it is important for showing, hiding, sharing, and deception.

Brooks and Meltzoff (2002) found that 12-, 14-, and 18-month-old infants followed the adult significantly more when the adult turned with open versus closed eyes. This runs against the leanest interpretation. We also found age-related developmental changes leading to this ability (Brooks & Meltzoff, 2005; Meltzoff & Brooks, 2007).

Understanding material things as blocking perception

Eye closure is only one way that a person's view can be blocked. Inanimate obstacles also can block one's view. Brooks and Meltzoff (2002, experiment 2) duplicated all aspects of the first study, using a headband and a blindfold. When the adult turns to look at a target with the headband on, she is visually attending to it; when she turns with a blindfold on, she is not.

The results showed that the 14- and 18-month-olds turned selectively to the target object in the headband case, but not the blindfold case. They seemed to grasp that the adult could not see in the latter case. In contrast, the 12-month-old infants did *not* distinguish between the two conditions. They systematically looked at the indicated target regardless of whether or not the adult's view was blocked by the blindfold or the headband. There is thus a puzzle: 12-month-olds understand that eye closure blocks the adult's view but not that blindfolds do. Why?

A Social-Cognition Training Study: Changing Infants' Understanding of Vision

The Like-Me theory offers a ready explanation. Eye closure is a biological motion with which infants have extensive first-person experience: infants control their own vision by closing their eyes when they do not want to look at something. The experience of turning off/on visual access through their own eye closing/opening serves as a framework for understanding the meaning of similar behaviors in others. Prediction: if infants are given extensive experience that blindfolds block their own view, they should make different attributions to others.

Accelerating social cognitive development

We designed an experimental intervention that provided blindfold experience to 12-month-old infants (Meltzoff & Brooks, 2008). Infants in the treatment group were provided objects on the table. When they turned to visually inspect an object, the experimenter held an opaque blindfold in between the object and the child's eyes (figure 2.3).

Two control groups were used. One used a windowed cloth. Infants received the same protocol but could peer through the slot. Infants in a baseline-control group were simply familiarized with the opaque blindfold (laying flat on the table).

At the end of training, infants in all three groups were presented with a blindfolded adult who turned toward the distal objects. The results showed that infants who had

Figure 2.3 A 12-month-old boy in Meltzoff and Brooks' (2008) training study. Infants in the experimental group were given self-experience with a blindfold. Infants looked at interesting objects (left). The blindfold blocked their view (right). This was repeated over a 7.5-minute training session with different objects. Infants used this self-experience to make inferences about other people's perception in a gaze-following test

received first-person training on the opaque blindfold did *not* turn. Infants who had the windowed-cloth experience or were in the baseline group still mistakenly followed the blindfolded adult's "gaze" to the distal object (replicating Brooks & Meltzoff, 2002).

Learning novel information about perception

In the natural course of development, infants change their understanding of visual perception. By 14–18 months of age, infants do not act as though adults can see through opaque barriers and refrain from following if an opaque barrier blocks the adult's view (Brooks & Meltzoff, 2002; Butler, Caron, & Brooks, 2000; Dunphy-Lelii & Wellman, 2004).

Meltzoff and Brooks (2008, experiment 2) provided 18-month-olds with novel self-experience that countered this expectation about opaque occluders. We designed a trick blindfold that looked opaque from the outside but was made of special material that could be seen through when held close to the eyes. Infants were randomly assigned to one of three groups: (a) experience with this trick blindfold, (b) experience with the opaque blindfold, and (c) baseline control (familiarity with the blindfold laying flat on the table).

After training, infants saw the adult wear the blindfold in the standard test. The finding was that infants who had first-person experience with the trick see-through blindfold followed the adult's head turns significantly more than did infants in the two other groups (figure 2.4).

These training effects showcase the power of like-me attributions by infants. The information infants learned through self-experience is immediately applied to others. As

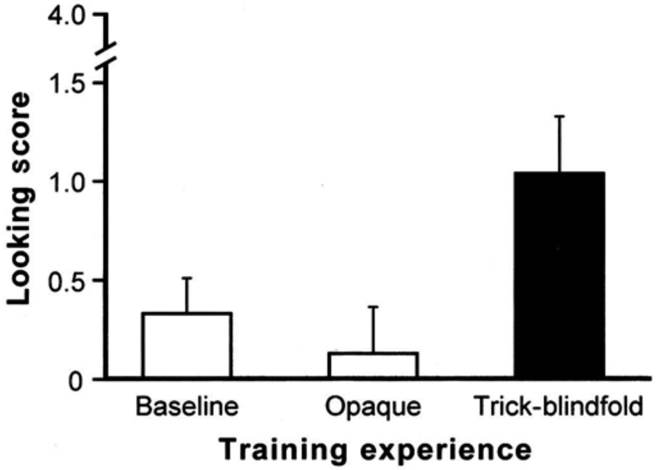

Figure 2.4 Infants learn new information through their own experience and immediately apply this to others. Infants who experienced the see-through, trick blindfold subsequently gaze-followed the blindfolded adult significantly more than controls. This is based on a "like-me" attribution (From Meltzoff & Brooks, 2008.)

they gain self-experience they flexibly transform their understanding of others *like me*: "If I can (or cannot) see in this situation, then another person in the same situation will have the same perceptual experiences." The child's understanding of others is thus not limited to what is preloaded in their mind; it changes as their own experience with the world increases.

Attributing Goals and Intentions

In adult social cognition, others are not only recognized as behaving "like me" and having perceptual experiences "like me," they also enjoy a palette of other mental states, including beliefs, emotions, and intentions just like my own (Searle, 1983; Stich, 1983).

Intentions are particularly interesting for developmentalists. A first question is whether infants have any inkling of the distinction between the actions someone performs and their goals and intentions in performing these actions. This is not an easy conceptual distinction. Wittgenstein (1953, p. 161) makes it clear: "What is left over if I subtract the fact that my arm goes up from the fact that I raise my arm?" Answer: Intention.

Intentions are mental states, and bodily movements are physical events in the world. The intentions themselves are not directly seen, heard, tasted, or smelled. Is there any evidence that infants read below the surface behavior and understand the intentions that lay behind them? How do they come to this (deep) interpretation of visible bodily acts?

Infant's understanding of others' unsuccessful attempts

The "behavioral re-enactment procedure" was designed to provide a non-verbal action measure for exploring infant intention reading (Meltzoff, 1995). The procedure capitalizes on children's natural tendency to re-enact or imitate, but uses it in a more abstract way to investigate whether infants can read below the literal surface behavior to something like the goal or intention of the actor (Bellagamba & Tomasello, 1999; Brandone & Wellman, 2009; Hamlin, Hallinan, & Woodward, 2008).

The experimental procedure involves showing infants an unsuccessful act. For example, the adult accidentally under- or overshoots his target, or he tries to pull apart a dumbbell-shaped toy but his hand slips off the ends and he is unsuccessful. Thus the goal-state is not achieved. To an adult, it is easy to read the actor's intentions although he never fulfills them. The experimental question is whether children read through the literal body movements to the underlying goal or intention of the act. The measure of how they interpreted the event is what they choose to re-enact, in particular whether they choose to produce the intended act despite the fact that it was never present to the senses. In a sense, the "correct answer" is not to copy the literal movement, but to copy the intended act that remains unfulfilled and invisible.

Meltzoff (1995) showed 18-month-old infants an unsuccessful attempt to reach a goal. The study compared infants' tendency to perform the target act in several situations: (a) after they saw the full-target act demonstrated, (b) after they saw the unsuccessful attempt to perform the act, and (c) after it was neither shown nor attempted. The results showed that 18-month-olds infer the unseen goals implied by unsuccessful attempts. Infants who saw the unsuccessful attempt and infants who saw the full-target act both produced target acts at a significantly higher rate than controls. Infants seemed to read through the surface behavior to the underlying goals or intentions of the actor. Evidently, toddlers can understand our goals even if we are unsuccessful in fulfilling them.

Infants understand goals not merely surface behavior. Another experiment underscored that infants in the behavioral re-enactment test are reading beyond the surface behavior of the adult. In this study, 18-month-olds were shown the unsuccessful-attempt display, and then handed a trick toy. The toy was surreptitiously glued shut (Meltzoff, 2007b). When children picked it up and attempted to pull it apart, their hands slipped off the ends of the cubes, matching the surface behavior of the adult. The question was whether this satisfied the children. It did not. They repeatedly grabbed the toy, yanked on it in different ways, and appealed to their mothers and the experimenter for help. They had matched the adult's surface behavior precisely, but were striving toward something else – the adult's goals, not his literal behavior. This work provides developmental roots for the centrality of goals in organizing imitative actions (Carpenter, Call, & Tomasello, 2005; Gattis, Bekkering, & Wohlschläger, 2002; Gleissner, Meltzoff, & Bekkering, 2000; Tomasello et al., 2005; Williamson et al., 2008).

Neuroscience evidence on goal-reading

Based in part on the developmental work, we designed brain-imaging work in adults to investigate the neural mechanisms involved in understanding other people's goals. In one study adults were shown (a) only the final step of an action sequence or (b) the means used by the adult, but with the film clip prematurely terminated, requiring participants to infer the unseen goal of the action sequence (Chaminade, Meltzoff, & Decety, 2002). The results showed that the medial prefrontal cortex was selectively activated when adults needed to infer the goal of the act. This fits well with the finding that this brain region is involved in other aspects of mentalizing or theory of mind (Blakemore & Decety, 2001; Frith & Frith, 1999; Liu, Meltzoff, & Wellman, 2009; Saxe et al., 2004).

Exploring what constitutes an intentional agent

Are there constraints on the types of entities that are interpreted to act in a goal-directed, intentional fashion? In the adult framework, only certain types of objects are ascribed intention. Chairs rock and boulders roll, but their motions are not seen as intentional. Most prototypically, human acts are the types of movement patterns that are seen as caused by intentions. (Animals and computers are borderline cases.) What do infants think?

Meltzoff (1995, experiment 2) tested how 18-month-olds responded to a mechanical device that mimicked the same movements as the actor in the failed-attempt condition.

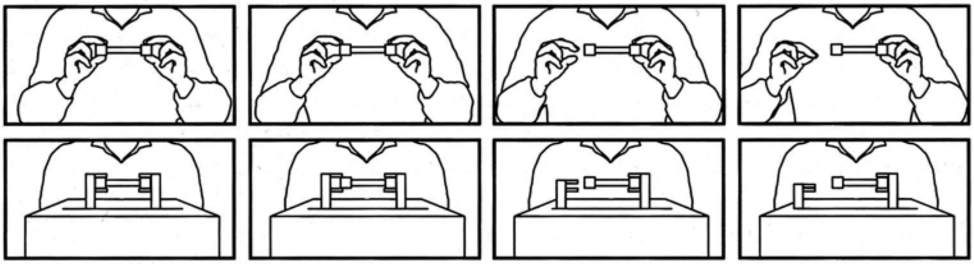

Figure 2.5 The events used to test infants' understanding of goals and intentions. The top row shows the unsuccessful attempt to separate the dumbbell by the human demonstrator. The bottom row shows a mechanical device tracing these same motions. Infants treated the former but not the latter within a psychological framework involving goals or intentions; see the text for details (From Meltzoff, 1995.)

An inanimate device was constructed that had poles for arms and mechanical pincers for hands. It did not look human but it could move very similarly to the human (figure 2.5, bottom panel). For the test, the pincers "grasped" the dumbbell at the two ends just as the human hands did. One mechanical arm was then moved outwards, just as in the human case, and its pincer slipped off the end of the dumbbell just as the human hand did. The movement patterns of machine and man were closely matched from a purely spatio-temporal description of movements in space.

Infants did not attribute a goal or intention to the movements of this mechanical device. Infants were no more (or less) likely to pull apart the toy after seeing the mechanical slippage of the inanimate device than in a baseline condition when they saw nothing.

Infants carefully watched the mechanical device and could learn certain things from it. This was demonstrated by another study in which the mechanical device succeeded (Meltzoff, 2007b). The device held the dumbbell from the two ends and successfully pulled it apart. When infants were given the dumbbell, they too pulled it apart. This makes sense because the infants then did not have to attribute goals or intentions. They simply had to reinstate what they saw – that the object was separated in two pieces. The important theoretical point is that infants only abstracted certain things (changes in the physical world) and not others (goals or intentions of the entity) from observing the behavior of the mechanical device.

I think 18-month-olds interpret the person's actions within a psychological framework that differentiates the surface behavior of people from a deeper level involving goals and intentions. When they see a person's hands slip off the ends of the dumbbell they infer what the adult was "trying" to do (which is different from what he did do). When they see the inanimate device slip off the end of the dumbbell, they see it as mechanical slippage with no implications for purposiveness. By 18 months of age and perhaps earlier, children have already adopted a fundamental aspect of a mature commonsense psychology – persons are understood within a framework involving goals and intentions.

Boundary conditions. It is possible that displays can be constructed that fool infants, as they do adults. Is a computer intentional? What about a goal-seeking robot?

We do not know the necessary and sufficient conditions for children's ascription of goals and intentions to entities, but research suggests that in certain circumstances infants ascribe goals to the movements of pretend humans (stuffed animals and puppets, Johnson, 2000; Johnson, Booth, & O'Hearn, 2001) and to dynamic displays that may be ambiguous as to whether they are of animate or mechanical origin (e.g., 2-D spots that leap, move spontaneously, and engage in mutual responsiveness, Gergely, chapter 3, this volume; Gergely, Nádasdy, Csibra, & Bíró, 1995).

This does not run against the thesis suggested here, but underscores the need for research on boundary conditions. The mechanical device used by Meltzoff (1995) gives a lower boundary (infants fail) and real people give an upper boundary (infants succeed). There is a lot of room in between for empirical research systematically manipulating relevant cues (e.g., Itakura et al., 2008).

Summary and Conclusions

Piaget (1952) argued that the infant is born a "solipsist." Fodor (1987) supposed that adult commonsense psychology was innately specified. Starting-state nativism offers a third way. My thesis is that a starting point for social cognition is that human acts are represented within a supramodal code that applies to self as well as others. Newborns bring this representation of human acts to their very first interactions with people. It provides an interpretive framework for understanding the behavior they see. Interpreting others as "like me" is our birthright.

It has long been thought that the commonality between self and other is integral to interpersonal relations (Husserl, 1977; Smith, 1976). Empathy, perspective-taking, and all manner of putting yourself in someone else's shoes rest on the connection between self and other (Jackson, Brunet, Meltzoff, & Decety, 2006; Lamm, Meltzoff, & Decety, in press). The way that the classic philosophers went wrong is that they thought the self–other equivalence was late to develop – emerging from language or complex cognitive analyses. The modern research on infancy stands this proposition on its head. It indicates that young infants can represent the acts of others and their own acts in commensurate terms. *The recognition of self–other equivalences is the starting point for social cognition, not its culmination.*

Given this facile self–other mapping, input from social encounters is more interpretable than supposed by Freud, Skinner, and Piaget. Infants have a storehouse of knowledge on which to draw: they can use the self as a framework for understanding the subjectivity of others. *Homo sapiens* begin the journey of social cognition armed with a common code, a *lingua franca*, that is more fundamental than spoken language.

We are not born social isolates. We are fundamentally connected to others right from the start, because they are seen as being "like me." This allows rapid and special learning from people (Meltzoff, Kuhl, Movellan, & Sejnowski, 2009). I can learn about myself and potential powers by watching the consequences of your acts, and can imbue your acts with felt meaning based on my own self-experience. As children's self-experience broadens, their appreciation of others' minds and behavior is enriched and refined. This propels infants beyond what they see or know innately. Social cognition rests on the fact that you are "like me," differentiable from me, but nonetheless enough like me to become my role model and I your interpreter.

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