PART I

Infancy: The Origins of Cognitive Development

The infant brain doubles in size during the first year of life. Although fetuses show both learning and memory (Hepper, 1992), most of the 1,000 trillion connections in the adult brain are formed during infancy and childhood (Gopnik, Meltzoff & Kuhl, 1999a). The number of actual brain cells (neurons) is virtually identical in infant and adult. What changes is the wiring. At birth, each neuron in the cerebral cortex has around 2,500 synapses. By the age of 2–3 years, each neuron has a staggering 15,000 synapses. By 2 years of age, the brain is already consuming glucose at adult levels. By 3, the little child's brain is actually twice as active as the adult's. It remains so until the child is 9 or 10. But pruning is as important as forming connections. Development consists of furious growth in connectivity and an associated pruning of old connections as the brain adapts itself to its surroundings and becomes more specialized.

This book is about how different aspects of cognitive development unfold during this period of peak sensitivity for learning. The plasticity of the child's brain is often remarked upon, but equally remarkable is the similarity in cognitive development across cultures and social contexts. In this first section on infancy, the authors focus on the basic kinds of knowledge that are central in human cognitive development. These are knowledge about social cognition, self and agency (Meltzoff, Gergely), knowledge about the physical world of objects and events (Baillargeon), and knowledge about the kinds of things in the world – conceptual knowledge (Quinn). These "foundational" domains (naïve psychology, physics, and biology) also depend on the development of memory (Bauer) and language (Waxman). Babies' experiences of the world continually lead them to enrich their possibly innate rudimentary understandings, to revise and modify them, and even to replace them with new understandings. Language and memory help them in this process.

The first chapter in this handbook considers the classical problem of how we come to know others as persons like ourselves. Based on his pioneering work in infant imitation, Meltzoff argues that the first common code between self and other is the ability to map the actions of other people onto the actions of our own bodies. He suggests that this imitative ability is innate, and argues that basic aspects of the representation of action must therefore also be innate. Furthermore, infants' ability to connect the seen acts of others with movements of their own (that they *feel* rather than see themselves make) is good evidence that certain cross-modal equivalences are present from birth. Meltzoff then summarizes the empirical evidence for early imitation. He shows that imitation is not simply an immediate mimicry of another's actions without any representation of those actions. It is not due to arousal, and it cannot be dismissed as a biologically based response that is released in the presence of certain signs. Rather, infant imitation is creative and open to modulation, and can occur hours or even days after the modeled event. Infants prefer to imitate people, not machines, and they can even associate certain people with certain imitative acts. Meltzoff argues that infants use information about whether a given person acts in a certain way to keep track of who that person is. Infants can also read the intention behind some adult acts by the age of around 18 months. At this point in development, they can watch unsuccessful actions and yet produce the intended target behavior. The idea that there is a language of human acts that is central to the development of human social cognition is an intuitively appealing one. Meltzoff's view is that seeing others as "like me" is central to the development of our ability to know other minds.

In his chapter on the development of understanding of the self as a causal agent, Gergely presents different evidence relevant to the same problem of knowing other minds. He addresses the traditional notion (stemming from Freud) that young infants are initially unable to distinguish themselves from their environments. He shows elegantly how unlikely this is, and argues that very simple cognitive skills such as the ability to detect contingency between events may underlie the development of an understanding of self and agency. Coupled with a probably innate propensity to attend to and interact with people, sensitivity to contingency may allow the infant to develop conscious awareness of their own emotional states and of how they are related to the actions of their caregivers. An important advance is thought to occur at around 9 months, when joint attention skills first start to appear, resulting in a new level of social-cognitive understanding of goal-directed rational action. This is at first focused only on the interpreter's own representations of reality, but eventually enables the development of an understanding of agency and of intentional mental states in others, which requires an understanding of the representations of other minds. Children become increasingly able to think in terms of mental causation during the second year onwards. Other people are represented in terms of generalized and enduring intentional properties, and this in turn brings about new levels of self-understanding. A cognitive representation of the self as an objective entity with enduring properties emerges at around the end of the second year. A full cognitive self-concept (possession of an abstract, temporally extended historical-causal concept of the autobiographical self) may not emerge until age 4 or 5, however.

Baillargeon summarizes current knowledge about infants' understanding of the physical world in eight "lessons" capturing the most recent findings from her laboratory. She discusses both the kinds of knowledge that infants possess, and the possible ways in which they might attain this knowledge. She suggests that infants first learn about physical events (such as occlusion, support, and collision) by forming rather specific primitive all-or-none rules consistent with innate core principles such as *solidity* and *continuity* and tied to their actual experience. With further concrete experience, they revise and elaborate these simple rules, taking account of different variables and reaching a more adult-like understanding of physical events. To demonstrate the critical role of experience, Baillargeon presents successful "teaching" experiments in which infants are given experiences that enable them to extract new variables at an earlier age than normally occurs. However, she also shows that they cannot extract arbitrarily manipulated variables that they cannot make sense of in terms of their prior physical knowledge. Baillargeon then considers whether the development of physical knowledge in infancy is best captured by a correlation-based model whereby infants absorb statistical regularities in the environment, or whether it is better described by a model of knowledge acquisition based on the detection of causal regularities. Given her teaching experiments, she argues that learning in infancy is "explanation-based," dependent on the ability of infants to construct causal explanations for new phenomena on the basis of their prior knowledge. As we will see in later chapters, older children appear to acquire knowledge of many kinds on much the same basis.

The absorption of statistical regularities in the environment can nevertheless be an important source of learning in infancy, as shown in the chapters by Quinn and Waxman. Quinn considers how infants go about the task of dividing the unlabeled world into like entities, which are then stored mentally as categorical representations. He begins from the premise that the perceptual world has structure in the form of bundles of statistically correlated attributes. Attention to these correlations may enable infants to carve up the world into entities such as dogs, people, cars, and trees. Quinn considers whether initial attention to correlation is at the "basic" categorical level of dogs and cars, or at the "superordinate" categorical level of animals and vehicles. Via a series of carefully controlled experiments, he demonstrates that very young infants proceed from more general ("animals") to more specific ("dogs," "cats") categorical representations. Quinn then develops a connectionist model of early categorization which suggests that this developmental sequence reflects the nature of perceptual learning. The learning process is very rapid, and basic-level categories dominate conceptual development by 3 to 4 months. These basic-level categories are very important for language acquisition, as of course the world is not really unlabeled for the infant. Caretakers are providing labels all the time, particularly for objects and actions, and such "open class" words are linguistically perceptually more salient too, receiving greater stress and having more interesting melodic contours.

Waxman, who makes this last point in her chapter, considers the close interaction between early conceptual development and early linguistic development in detail. She argues that a parsimonious explanation of the highly similar forms that conceptual and linguistic development take across very different cultures is that infants are born equipped with an innate expectation that words will refer to commonalities among objects. These commonalities can be of many kinds, for example taxonomic (dogs, cats), functional (pulls, cuts), thematic (bread goes with butter), or property-based (has wings, is red). As in Baillargeon's account, the initial core expectation is assumed to be fine-tuned via experience. As in Gergely's account, there is also a causal role for infants' innate propensity to attend to and interact with other people. Infants show a special interest in "people sounds" – the sounds of language. They rapidly become perceptually tuned to the phonologic, prosodic, and morphologic elements characterizing their native language, and very soon, novel words guide attention to objects and highlight commonalities and differences between them. Language itself plays a role in what is attended to: Waxman shows that infants learn that novel nouns signify categories of objects (balls), and that novel adjectives signify properties of objects (red). There is also a role for the understanding of agency: Waxman argues that infants can only map words to their referents if they can infer that the speaker *intended* to name the designated object. She then illustrates how naming promotes the formation of object categories, and demonstrates the importance of the "basic level" of object categorization in this process. Waxman ends by agreeing with Quinn that basic-level categories are probably *not* perceptually based.

The acquisition of all the different kinds of knowledge covered in these first chapters relies on infants having relatively well-functioning memories. Bauer's chapter discusses the relevant evidence. She demonstrates that the traditional view (stemming from Piaget) that infants were unable to represent information that was not currently available to their senses was misguided. This view stemmed partly from the lack of suitable paradigms within which to examine infant memory. Bauer shows that the development of new paradigms such as infant habituation and deferred imitation has enabled the documentation of really quite remarkable mnemonic capacities in infancy. Although very young infants appear to form very specific memories for events (as in Baillargeon's experiments), older infants of around 6 months form more general memories based on categorical information. Temporally ordered recall memory is present by at least 9 months, which is thought to be an important age for the development of long-term recall ability on the basis of electrical evoked potential evidence (note that this is the same age at which Gergely described a social-cognitive revolution in understanding goal-directed actions). Infants can benefit from cues designed to facilitate recall by at least 18 months, and with contextual support 2-year-olds can recall events that occurred around six months previously. By 3 years of age, children can provide verbal reports of events that occurred when they were 20 months old. Bauer demonstrates that some of these developments probably depend on the maturation of different brain structures. Memory functions subserved by the medial temporal lobes may develop relatively early, whereas those subserved by the association areas may develop more slowly. She concludes that there is great continuity in memory from infancy to early childhood and beyond.

Indeed, continuity seems to be the rule rather than the exception in all of the developmental domains discussed in this section. Each chapter illustrates ways in which the foundational domains of cognition are functioning from the earliest months. In contrast to traditional theories, current cognitive developmental psychology does not characterize the newborn as incapable of distinguishing self from other, incapable of forming representations and incapable of retaining memories. Rather, newborns are characterized as active learners, equipped with certain innate expectations which, although quite primitive, enable them to benefit hugely from experience. Experience of the physical and social worlds allows infants to enrich and revise these initial expectations, and even to replace them with new understandings. A number of potentially innate or very early-developing abilities are outlined in this section. These abilities include imitation, the perception of contingency, attending to people, assuming physical principles such as solidity and continuity, and expecting words to refer to commonalities among objects. Three learning mechanisms are also discussed: (1) the absorption of statistical regularities from the environment, as in conceptual learning and perceptual tuning to language; (2) making relational mappings, as in mapping the actions of other people onto the actions of one's own body, or mapping the responses of another person to one's own emotional states; and (3) "explanation-based" learning, comprising the detection of causal regularities in environmental information and the seeking of explanations for them. As we will see, these themes concerning innate or core principles of knowledge and likely mechanisms of learning (perceptual, motor/action-based, and cognitive/reflective) recur in many later chapters as well.

CHAPTER ONE

Imitation as a Mechanism of Social Cognition: Origins of Empathy, Theory of Mind, and the Representation of Action

Andrew N. Meltzoff

There is a kinship between the philosophical problem of "other minds" and the psychological problem of imitation. Philosophers are struck by the fact that people experience their own mental states differently than they register mental states in others. We experience our own internal thoughts, plans, and feelings but do not see ourselves from the outside. We perceive visual and auditory signals emanating from others, but do not directly experience their feelings. "Only connect!" (E. M. Forster), but how can we connect when we know each other in such incommensurate ways?

For developmental scientists and neuroscientists, imitation poses the other minds' problem in action. Infants can see an adult's face, but cannot see their own faces. They can feel their own face move, but have no access to the feeling of movement in others. How can infants connect the seen movements of others with acts of their own they only feel themselves make?

For the newborn, "only connect" is a matter of life and death. Which entities out there are conspecifics and what is the lingua franca of connectivity? What is the common code between self and other?

Classical theories of human development from Freud and Piaget to Skinner all agree on one axiom. Newborn infants have no inkling of the similarity between self and other.

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Correspondence concerning this chapter should be addressed to Andrew N. Meltzoff, Center for Mind, Brain, and Learning, Box 357920, University of Washington, Seattle, WA 98195. Email: Meltzoff@u.washington.edu; Fax: 206-221-6475.

A primary task of cognitive development is to build a connection to others, causing the child to realize they are "one of us" and share desires, intentions, and emotions with other humans. The progression is from social isolate to social partner.

New empirical work has shaken this view to its foundations. It suggests that evolution provides the newborn with a grasp that others are "like me" and an innate propensity to imitate them. This innate foundation in turn provides an engine and mechanism for the growth of social cognition. It has bidirectional developmental effects. As infants' knowledge of themselves expands, they use this new psychological structure as a framework for interpreting others. Reciprocally, novel acts of others change the infant's mind and brain because the self is modeled on others right from birth. The result is a child who discovers facets of other minds through analogy with their own mind and who simultaneously discovers powers and possibilities of the self through observing others.

This chapter will link the imitative nature of the newborn and the developing theory of mind of the toddler. *The developmental hypothesis is that Nature's solution to the imitation problem gives babies the tools they need to crack the problem of other minds.* Imitative experience with other people serves as a "discovery mechanism" for social cognition, engendering interpersonal understanding that outstrips the innate givens and leads to empathy, perspective-taking, and theory of mind. Moreover, there are intriguing parallels between young children's growing cognition about people and their understanding about inanimate things. The focus of this chapter is social cognition, but as we shall see, the lessons apply much more broadly to general theories of developmental psychology (see also Gopnik, Meltzoff, & Kuhl, 1999b; Meltzoff & Moore, 1998b).

Classical Views of Newborns

On classical views of human development, the newborn is cut off from others. 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 the 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. Freud's powerful metaphor for the newborn – which influenced generations of psychoanalysts – is as follows:

> 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)

Piaget's newborn is similar, although Piaget reaches for a philosophical rather than ornithological metaphor. Piaget (1952c, 1954) claimed the baby is "solipsistic." The neonate has only a few reflexes to work with (e.g. sucking, grasping), and other people are registered only to the extent that they can be assimilated to these action schemes. The baby only knows his or her own actions. The child battles its way out of solipsism by 18 months. This is a very long road to understanding other people:

> 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)

Skinner (1953), an animal behaviorist, gave his blank-slate infant even less to work with. One cannot really quote from Skinner about how children crack the puzzle of social cognition, because, in a sense, he does not think they ever do. Even adults are conceptualized as reacting to behaviors but not knowing the minds of their interactive partners. Human beings have exquisite contingency detectors and that is all there is. To use Skinner's phrase, social cognition is largely a "matter of consequences" (Skinner, 1983).

Two Types of Nativism

Empirical work over the past 25 years revealed a much richer innate state than Freud, Piaget, and Skinner had posited. The nativists won the battle over the newborn's mind and this applies both to infants' understanding of people (Gergely, ch. 2, and Wellman, ch. 8, this volume) and things (Baillargeon, ch. 3 this volume). But two distinct schools of nativism seem to be shaping up and the distinction is especially pronounced regarding social cognition. One view, "starting-state nativism," argues that radical conceptual revision begins at birth (e.g., Gopnik & Meltzoff, 1997; Meltzoff & Moore, 1998b). The other, "final-state nativism," argues that the initial state is equivalent to the final state. As a final-state nativist, Fodor believes that the adult theory of mind is innate:

> 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 posses the mature theory of mind. Why spend time learning it? Spelke is also a final-state nativist, chiefly concerning infants' reasoning about physical objects (e.g., Spelke, Breinlinger, Macomber, & Jacobson, 1992). She argues that infants have the same core knowledge as adults and that age-related behavioral change is due to biological maturation and the lifting of performance constraints which block infants from expressing their true knowledge.

In the starting-state view, infants have innate knowledge and are endowed with tools for constructing an adult-like theory – but the newborn does not innately possess the adult theory. Evolution has provided the newborn with powerful discovery procedures for developing adult cognition, but the final state is not specified at birth or achieved through constraint removal. The view is not standard Piaget, because the innate toolkit is wholly different, with far-reaching implications for the trajectory of development.

Jump-Starting Theory of Mind

If the infant is not born with the adult model of mind, how do they come to it? Skinnerian blank slates, Freudian isolated eggs, and Piagetian solipsism won't get us from the newborn to the adult, because there is not enough innate structure to make good use of the experience received in social interaction.

Starting-state nativism proposes that three factors give human infants a jump-start on developing a theory of mind.

(a) *Innate equipment.* Newborns detect equivalences between observed and executed acts. When newborns see adult biological motion, including hand and face movements, these acts are mapped onto the infant's body movements. This mapping is manifest by newborn imitation. Newborn imitation suggests an innate common coding of human acts whether these body transformations are performed by self or observed in other (Meltzoff & Moore, 1997; Meltzoff & Prinz, in press).

(b) *First-person experience.* 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 of concentration and effortful bodily acts. Infants experience their own unfulfilled desires and their own matching facial/postural/vocal reactions. They experience their own inner feelings and outward facial expressions and construct a detailed bidirectional map linking mental experiences and behavior. In other words, they learn quite a bit about themselves in everyday life.

(c) *Inference to others.* When infants see others acting in a way that is similar to how they have acted in the past, acting "like me," infants project that others have the mental experience that is concomitant with those behavioral states themselves. This gives infants a window into understanding others before spoken language can be used.

Infants would not need the adult theory of mind preloaded. Infants could infer the internal states of others through an analogy to the self. This is not Fodorian nativism – newborns do not possess the adult theory. But they use special neural-cognitive machinery and experience with their own acts to structure their interpretations of others. Infants' understanding of their own internal states and bodily acts, coupled with their innate grasp that others are "like me," kick starts their understanding of other minds. The remainder of this chapter grounds this general argument in new empirical work from infancy and cognitive neuroscience.

Facial Imitation: The Representation of Human Actions

Early imitation suggests that infants can detect the equivalences between self and other. Of course, the idea that infants have a rapport with other people is not a new one. It is expressed in Trevarthen's (1980) idea of "primary intersubjectivity" and extended by Stern (1985), Bruner (1983), Hobson (1989), and Jaffee, Beebe, Feldstein, Crown, & Jasnow (2001). However, these authors see the origins of intersubjectivity in the timing of infant-adult turn-taking and gestural "dances." Timing is important, but it is not everything: There seems no clear reason why temporal contingencies, by themselves, should lead infants to think of other people as like themselves in deep ways. Other entities can move as a consequence of my movements and still not be like me in any fundamental way. Similarly, some theorists believe that infants are innately endowed with a special visual attentiveness to the human face (Johnson & Morton, 1991). However, facial pattern detectors, in themselves, also do not provide a link between the self and the other. The adult face may be a particularly arresting visual entity, but why should infants think of this visual entity as someone connected to themselves?

Starting-state nativists seek the origins of social cognition in the representation of human acts. We propose that *infants' connection to others emerges from the fact that the bodily movement patterns they see others perform are coded as like the ones they themselves perform.* Twenty-five years of research on imitation has revealed quite a bit about the nature of this innate interpersonal mapping. The power of what has been discovered about the innate state cannot be grasped without a synopsis of the data, to which we now turn.

Nature and scope of early imitation

Meltzoff and Moore found that 12- to 21-day-old infants imitated tongue protrusion, mouth opening, lip protrusion, and hand movements. Infants responded differentially to two types of lip movements (mouth opening vs. lip protrusion) and two types of protrusion actions (lip protrusion vs. tongue protrusion). More recent research demonstrated that infants differentiated two different types of tongue protrusions from one another, straight tongue protrusion versus tongue out to the side of the mouth (Meltzoff & Moore, 1994, 1997). Thus the response was quite specific; it was not a global or a general arousal reaction.

There is also evidence that early matching is not simply restricted to immediate mimicry. In one study a pacifier was put in infants' mouths as they watched the display so that they could only observe the adult demonstration but not duplicate the gestures. After the infant observed the display, the adult assumed a passive face pose and only then removed the pacifier. After the pacifier was removed, the infants imitated the earlier displays (Meltzoff & Moore, 1977). Other research documents imitation after the memory delay is as long as one day. Six-week-old infants came in on one day, observed the gestures, and went home. They then returned the next day and were presented with the experimenter sitting motionless with a passive face. Infants successfully imitate based on their remembrance of things past (Meltzoff & Moore, 1994). If yesterday's adult had shown mouth opening, the infants initiated that gesture; if the adult had shown tongue protrusion, infants greeted him with that gesture.

Research also reveals that the response is not rigidly fixed or stereotypic. Infants correct their imitative attempts so that they more and more closely converge on the model demonstrated. For example, if the adult shows a novel gesture such as tongue-protrusion-to-the-side-of-the-mouth, infants will begin with ordinary tongue protrusions. They use the proprioceptive feedback from their own actions as the basis for guiding their response to the target (Meltzoff & Moore, 1994). Also, there was a revealing error that occurred significantly more often to the tongue-to-the-side display than any control gestures. Infants poked out their tongues and simultaneously turned their heads to the side (Meltzoff & Moore, 1997). Although the literal movements were very different, the goals are similar. Tongue protrusion + head turn was not the work of a mindless reflex. It was a creative error.

The subjects in the previous studies were 2 to 6 weeks old. At first glance this seems young enough to justify claims about an innate capacity. But perhaps neonates had been conditioned to imitate during the first weeks of life. Perhaps imitation was dependent upon earlier mother–infant interaction. To resolve the point, Meltzoff and Moore (1983) tested 40 newborns in a hospital setting. The average age of the sample was 32 hours old. The youngest infant was only 42 minutes old. The results showed that the newborns imitated both of the gestures shown to them, mouth opening and tongue protrusion. These findings were subsequently replicated using different gestures in newborns under 72 hours old (Meltzoff & Moore, 1989). Nativist claims are, of course, commonplace in the literature, but there are few cognitive capacities that have actually been demonstrated to be present at birth. You can't get much younger than 42 minutes old. These data directly demonstrate that a primitive capacity to imitate is part of the normal child's biological endowment.

Beyond arousal or an automatic sign-released response

Although early imitation was initially considered a surprise, the effect has now been replicated and extended in more than 25 different studies from 13 independent labs, including those from the US, England, Canada, France, Switzerland, Sweden, Israel, Greece, Japan, and even in rural Nepal (for literature reviews see Meltzoff & Moore, 1994, 1997). This research effort has uncovered several interesting characteristics of early imitation (table 1.1). Collectively, these characteristics contradict attempts to explain the imitative effects as (a) arousal or (b) a sign-released response. They show that – no matter how difficult for theory – we must abandon the classical theories of neonatal "solipsism."

Three well-replicated findings disprove the arousal interpretation.

(a) Proponents of arousal assume that a tongue protrusion display has a special arousal property. They predict it should be the only gesture imitated. The empirical findings worldwide demonstrate that a range of gestures can be imitated, including both facial and manual gestures, which directly counters the arousal interpretation (see table 1.1, point 1).

(b) Infants imitate static poses. This contradicts the notion that the visual movement alone is stirring up the response through arousal (table 1.1, point 2).

(c) Infants can imitate from memory in the absence of the (purportedly) arousing stimulus. No arousal is possible in this case because the infant is watching a passive face (table 1.1, point 3).[1]

Table 1.1 Characteristics of early imitation

Evidence that early imitation is not due to arousal

1. Infants imitate a range of acts, not just tongue protrusion
   Field, Goldstein, Vaga-Lahr, & Porter, 1986; Field et al., 1983; Field, Woodson, Greenberg, & Cohen, 1982; Fontaine, 1984; Heimann et al., 1989; Heimann & Schaller, 1985; Kugiumutzakis, 1985; Maratos, 1982; Meltzoff & Moore, 1977, 1989, 1994; Vinter, 1986
2. Nonmoving gestures can be imitated
   Field et al., 1986; Field et al., 1983; Field et al., 1982; Meltzoff & Moore, 1992
3. Perceptually absent stimuli are imitated
   Fontaine, 1984; Heimann et al., 1989; Heimann & Schaller, 1985; Legerstee, 1991; Meltzoff & Moore, 1989, 1992, 1994

Evidence that early imitation is not an automatically triggered, released response

4. Novel and unfamiliar acts can be imitated
   Fontaine, 1984; Meltzoff & Moore, 1994, 1997
5. Infants make errors on movements, but accurately recruit correct body part
   Kugiumutzakis, 1985; Meltzoff & Moore, 1983, 1994, 1997
6. Infants correct their imitative efforts
   Kugiumutzakis, 1985; Maratos, 1982; Meltzoff & Moore, 1994, 1997
7. Infants imitate from memory in the absence of the trigger stimulus
   Fontaine, 1984; Heimann et al., 1989; Heimann & Schaller, 1985; Legerstee, 1991; Meltzoff & Moore, 1989, 1992, 1994

Three replicated sets of findings are incompatible with the releaser interpretation:

(a) Infants imitate novel gestures and commit creative errors, demonstrating remarkable flexibility and lack of automaticity (table 1.1, points 4 and 5).
(b) Infants correct their responses to more faithfully match the model, thus showing feedback modulation, not the triggering of a fixed reaction (table 1.1, point 6).
(c) Infants can imitate from memory. The trigger for the (purported) reflex is nonexistent. It makes no sense to say that yesterday's stimulus triggered today's reflex after a 24-hour pause (table 1.1, point 7).

For most developmentalists interested in imitation, the key for the future lies in exploring the neural and psychological mechanisms underlying this early matching behavior and the role it serves in the infant's *Umwelt*. Excellent progress has been made.

Psychological mechanism

Meltzoff and Moore suggested that imitation is based on infants' capacity to register equivalences between the body transformations they see performed by other people and the body transformations they only feel themselves make. On this account, facial imitation involves crossmodal matching. Infants can, at some primitive level, recognize an equivalence between the acts they see others do and the acts they do themselves. There appears to be a very primitive and foundational "body scheme" that allows the infant to unify the seen acts of others and their own felt acts into one common framework. The infant's own facial gestures are invisible to them, but they are monitored by proprioception. Conversely, the adult's acts are not felt by proprioception but they can be seen. Infants can link observation and execution through a common "supramodal" coding of human acts. This is why they can correct their imitative movements. It is why they sometimes make interesting errors. And it is why they can imitate from memory: infants store a representation of the adult's act and it is the target against which they compare their own acts. Imitation is intentional, goal-directed activity. A detailed description of the metric infants use for establishing the crossmodal "common framework" between self and other is provided elsewhere (Meltzoff & Moore, 1997).

Brain bases

Recently, the work on neonatal imitation has been buttressed by neuroscience research, which has uncovered remarkably compatible findings. The new neuroscience research shows that a certain set of brain regions (in frontal and posterior parietal lobes) is activated both by observing and by performing motor movements, the so-called "mirror system" (Decety, in press; Decety et al., 1997; Decety & Grèzes, 1999; Fadiga et al., 1995; Rizzolatti et al., 1996). Thus, there are two lines of research documenting a close coupling between seeing and doing acts: (a) modern neuroscience showing that specific neural regions subserve both observation and execution of movements, and (b) developmental research showing that newborns execute certain motor acts based on observation. Taken together, these converging lines of research validate the idea that imitation is fundamental to humans' mental makeup (for neuroimaging studies on adult imitation making a similar point, see: Chaminade, Meltzoff, & Decety, in press; Decety, Chaminade, & Meltzoff, in press; Iacoboni, Woods, Brass, Bekkering, Mazziotta, & Rizzolatti, 1999).

People as Individuals: Imitation and Numerical Identity

There are some basic aspects of social cognition that neonates don't grasp. One of their most surprising immaturities concerns the understanding of the *identity* of people. Keeping track of the identity of individuals is fundamental to adult social cognition. In *Star Trek*, the Borg are not individuals but a collective; but for human mortals, social relationships are not an oceanic feeling of connectedness to an undifferentiated universe of others. Adult social cognition arises from one's relation to specific others, each valued for their individuality. There is evidence showing that infants are very concerned about tracking the identity of individual people in time and space.

Identity is most often discussed in relation to inanimate objects (e.g., Meltzoff & Moore, 1998b; Spelke, Kestenbaum, Simons, & Wein, 1995; Xu & Carey, 1996).

However, the same issue arises with regard to people. Here it is crucial to distinguish two meanings of "sameness" or "identity." One meaning of "the same" concerns an entity being the self-same individual over different encounters in space and time. This is often called "numerical identity," because there is one object that meets the definition of "this same object." A different meaning concerns an object's appearances or features. This is often referred to as "qualitative" or "featural identity." Identical twins differ in numerical identity but are featurally identical. My soft-drink can and yours can be featurally indistinguishable; yet they are different individuals. Investigations of object permanence are typically concerned with numerical identity – "Is this the self-same object again?" (Meltzoff & Moore, 1998b; Moore & Meltzoff, 1999); investigations of categorization are chiefly concerned with qualitative identity – "Is this exemplar the same kind as the other?" (Quinn, ch. 4 this volume).

Using imitation to keep track of people

Although the role of qualitative identity in social cognition has long been recognized (e.g., infants' ability to categorize happy vs. angry faces or male vs. female faces – and their social responses to those general categories), the importance of numerical identity to social cognition has been underappreciated. Attachment and romantic love (not to mention custodianship of bank accounts) depend on distinguishing numerical versus qualitative person identity. How does an infant individuate one person from another and re-identify a person as the "same one" again after a break in perceptual contact – as someone with whom I have this relationship? This can be posed as a baby-sized problem.

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. 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). The experiment required that infants keep track of the two different people and their gestures (Meltzoff & Moore, 1992).

When infants visually tracked these exchanges they imitated each person without difficulty. 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 the two actors. Instead, infants stared at the new person . . . paused (often with wrinkled brow) . . . and then intently produced the *previous* person's gesture. It appeared that in the absence of clear spatiotemporal evidence of twoness (visual tracking of the entrances and exits), infants became confused: is it the same person with a different appearance, or a new person in the old place?

What can a young infant do to resolve this identity confusion? I believe that when infants are ambiguous about the identity of a person they see (e.g., because of a break in spatiotemporal contact), they are motivated to test whether this person *acts* in a certain way. For young infants, body-actions and expressive behavior of people are identifiers of who people are. At least with regards to people, infants use functional criteria in addition to spatiotemporal and featural criteria for determining numerical identity.

I think infants deployed imitative reactions to sort out their questions about the identity of the person they saw. That is why they stared at the new person and did the old person's signature gesture. It is their way of asking: "Are you the same person I saw before? Are you the one who does *x*?" Other studies on imitation and identity reinforce this point (Meltzoff & Moore, 1994, 1995, 1998b). Distinctive behavior and interactive games serve as markers of people's identity. Identity questions motivate the imitative re-enactment and imitation of people's acts.

People as Perceivers: Infant Gaze-following

We do not live in a world solely of people. We are surrounded by objects and many of our thoughts and wants are directed toward these objects. Neonates enjoy something like a conceptual Garden of Eden – populated by self and others 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, despite the infant's own charming bids for attention.

In the adult psychological framework, head and eye movements have special significance. We realize that others direct their attention toward objects, picking up information about them from afar, despite the spatial gap between attender and target. 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 (even biological movements) with no notion that they are *directed toward* the external object – no referential value? If they start off meaningless, how do simple bodily movements come to gain such value?

Research has been aimed at understanding these issues. The data demonstrate that young infants follow another's gaze, but there is debate about the mechanism mediating this behavior (Baron-Cohen, 1995; Baldwin & Moses, 1994; Bruner, 1999; Butterworth, 1991; Moore, 1999; Moore & Dunham, 1995; Scaife & Bruner, 1975). Proponents of a conservative stance argue that infant gaze-following is based on their being attracted to the spatial hemi-field toward which the adult's head is moving. A young infant visually tracks the adult's head rotation and thereby swings its own head to the correct half of space without any notion of the adult's "attention to an object" (e.g., Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991; Moore & Corkum, 1994). On this view, infants do not really process the adult as a perceiver/looker, but simply process the salient movement of the head regardless of what the genuine organs of attention – the eyes – are doing (Corkum & Moore, 1995; Farroni, Johnson, Brockbank, & Simion, 2000; Moore & Corkum, 1998).

Interpreting gaze-following

We recently focused on the question of whether infants understand the "object directedness" or referential value of adult attentive movements (Brooks & Meltzoff, 2001). In the study, two identical objects were used, and the adult turned in silence with no verbal or emotional cues. The infants were 12, 14, and 18 months of age. The interesting manipulation was that the adult turned to the target object with *eyes open* for one group and with *eyes closed* for the other group. In each case infants interacted contingently with the adult before the trial. If infants relied on gross head motions (Butterworth & Jarret, 1991), they should turn regardless of whether the adult's eyes were open or closed, because the head movement was identical. If they relied on an abstract rule to look in the same direction as a "contingent interactant" (Johnson, Slaughter, & Carey, 1998), they should also look whether the adult's eyes were open or closed, because the adult's interactive behavior was identical in both groups.

The findings showed that the infants turned selectively – they looked significantly more often toward the target object when the adult turned toward it with eyes open than eyes closed. The results were significant at each age group taken alone. One interpretation is that as early as 12 months infants begin to realize that the same person may either be looking/attending or not, depending on the status of his or her perceptual systems.

Closing one's eyes is a body movement performed by the adult. Infants have a good deal of experience with closing their own eyes and thereby cutting off their own visual perception. Perhaps this gives them leverage for understanding this act in others. Eye closure is only one way that a person's view can be blocked. Inanimate obstacles can also block one's view. Brooks and Meltzoff (2001) ran another experiment, duplicating all aspects of the first, but using a headband and a blindfold. When the adult turns to look at a target with the headband on, she is attending to it; when she turns with a blindfold on, she cannot be attending to it. The results showed that the 14- and 18-month-olds turned selectively to the appropriate target object only in the headband case. Interestingly, the 12-month-olds turned to look at the target even when the adult wore a blindfold that blocked her eyes. They did not seem to interpret the blindfold in the same way as eye closure. One interpretation is that infants may understand eye closure earlier (12 months) than blockage by an inanimate screen (14 months) in part because of experience with their own eyes.

In fact, Brooks and I noticed two responses that have not been systematically investigated in the joint visual attention literature. We think that these responses provide critical clues about the mechanism underlying gaze-following. First, we discovered that infants pointed to the target object significantly more often if the adult looked at it with open versus closed eyes. This supports the idea that it was not simply adult head movements dragging the child's head movements. The infant's response involved a different motor movement than the adults'. The goal was the same, making reference to an object, but the means was different.

Second, we selected those trials with accurate looking and measured the duration of infants' visual examination of the target object. Infants visually inspected the object longer when they were guided there by the adult with open eyes versus closed eyes. Of course the object, in itself, is the same toy in both cases. The physical object has not changed, but the infant's attention to it significantly changes. We propose that the object takes on special valence because it is the object-of-someone-else's-attention. Infants visually inspect the object longer when it is referenced by another attender.

Taken together, the pointing and visual examination data suggest that infants are not simply observing meaningless motions. Infants are not simply coding physical motions, but are making a psychological attribution to the gazer. The findings do not prove that infants ascribe to the adult an "internal experience of attending," but they certainly move beyond the most conservative stances about infant gaze-following. At minimum, they suggest that infants in the second year represent the "object-directedness" of adult gaze. They see the head movements as directed toward the external world and not as mere bodily movements without significance (see also Brooks, 1999; Butler, Caron, & Brooks, 2000; Johnson, 2000; Wellman & Phillips, 2001; Woodward, Sommerville, & Guajardo, 2001). In the conclusions of this chapter, we will propose a theory of how infants' own experience with cutting off and re-accessing the visual world through their own eye opening-closing could contribute to their understanding of the role of eyes in the visual perception of others.

People as Intenders: Understanding Goals of Acts

In the mature adult social cognition, other people not only act "like me," and have perceptual experiences "like me," they also enjoy a palette of other mental states, including beliefs, emotions, and intentions (Goldman, 1993, 2001; Searle, 1983; Stich, 1983). Intentions are particularly interesting for developmentalists. Indeed, a first question is whether infants have any inkling of the distinction between the actions someone performs and their intention in performing these actions. This is not an easy conceptual distinction. Wittgenstein (1953) makes it clear with a blunt question: "What is left over if I subtract the fact that my arm goes up from the fact that I raise my arm?" Answer: intention.

As Wittgenstein's example shows, intentions are not reducible to bodily movements. Intentions are mental states and bodily movements are physical events in the world. The two have an intimate relation because intentions underlie and cause bodily movements, and reciprocally, one can read intentions from body movements. But the intentions themselves are not directly seen, heard, tasted, or smelled. The developmental problem is clear and irresistible: Is there any evidence that infants read below the surface behavior and understand the intentions that lie behind them? How do they come to this interpretation of bodily acts?

To address these questions, it is not enough to explore whether young children act intentionally themselves; we need to investigate whether they understand the intentions of others. There is excellent research on this topic using verbal tests with 3- and 4-year-old children (Zelazo, Astington, & Olson, 1999; Flavell, 1999; Malle, Moses, & Baldwin, 2001; Moses, 1993; Taylor, 1996). Many investigators are now examining the origins of intention-reading using nonverbal techniques.

Reading people's goals

The "behavioral re-enactment procedure" was designed to provide a nonverbal technique for exploring intention-reading (Meltzoff, 1995a). 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.

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 dumb-bell-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 to not copy the literal movement, but the intended act that remains unfulfilled and invisible.

Meltzoff (1995a) showed 18-month-old infants an unsuccessful act, a failed effort. 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 can 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 fail to fulfill them.

At what age does this understanding of others emerge? The results suggest that it develops between 9 and 15 months of age. I have found that 15-month-olds behaved much like the 18-month-olds in the original 1995 study, but 9-month-olds did not respond above baseline levels to the failed-attempt demonstrations (Meltzoff, 1999). Importantly, control conditions indicated that 9-month-olds succeeded if the adult demonstrated successful acts. Thus, the 9-month-olds imitated visible acts on objects, but gave no evidence of inferring intentions beyond the visible behavior itself. This finding of a developmental change in infants' understanding of others' goals and intentions has been documented in other studies as well (Bellagamba & Tomasello, 1999; Wellman & Phillips, 2001; Woodward et al., 2001). So there is converging evidence for an important developmental change between 9 and 15 months.

If infants can pick up the underlying goal or intention of the human act, they should be able to achieve the act using a variety of means. This was tested in a study of 18-month-olds using a dumb-bell-shaped object that was too big for the infants' hands (Meltzoff, 1996). The adult grasped the ends of the dumb-bell and attempted to yank it apart, but his hands slid off so he was unsuccessful in carrying out his intentions. The dumb-bell was then presented to the child. Interestingly, the infants did not attempt to imitate the surface behavior of the adult. Instead they used novel ways to struggle to get the gigantic toy apart. They might put one end of the dumb-bell between their knees and use both hands to pull it upwards, or put their hands on inside faces of the cubes and push outwards, and so on. They used different means than the experimenter, but toward the same end. This fits with Meltzoff's (1995a) hypothesis that infants had inferred the goal of the act, clearly differentiating it from the literal surface behavior that was observed.

Other techniques assessing goal-reading in infants. The foregoing analysis focuses on the behavioral re-enactment procedure, but for completeness, it is worth noting that this is not the only technique used in the preverbal period. Other researchers have used the visual habituation procedure to investigate infants' understanding of goal-directed actions (e.g., Gergely, ch. 2 this volume; Woodward et al., 2001; Wellman, ch. 8 this volume). The habituation procedure differs from the behavioral re-enactment procedure in a couple of interesting ways. First, it does not measure infant re-creations of events in *action*; it tests whether they choose to *look* longer at one display or another (the former is like an essay exam and the latter like a multiple choice). Second, the habituation procedure does not ask precisely the same questions as the behavioral re-enactment approach. For example, Woodward (1998, 1999) showed infants an adult grasping an object that appeared in either of two locations. The question was whether infants treated the object as the "goal of the reach." Note that the "goal" of the reach is the *seen* physical object (a toy ball or bear). This differs from the re-enactment procedure in which the goal is an *unseen* act the adult was "trying" to achieve but did not. In the behavioral re-enactment procedure the goal is not visible and has to be inferred; in Woodward's habituation technique, the goal object is visible to the infant.

Similarly, Tomasello investigated goal-reading, and also used an approach that is distinct from the behavioral re-enactment procedure (Tomasello & Barton, 1994; Tomasello, 1999). He showed infants well-formed successful acts versus ill-formed accidental-looking acts. The results showed that infants choose to imitate the former. Tomasello interpreted the data as showing that intentionality has a special valence for infants; they prefer to imitate intentional actions. A more conservative reading might be that infants preferentially imitate well-formed acts just because they are cleaner motor sequences – less messy and jerky than the "accidental" ones. If so, infants could preferentially imitate without understanding the intentionality behind these acts. Also note that in Tomasello's paradigm infants imitate what they see, and the question is which of two acts they see they prefer to copy. Again, the special characteristic of the re-enactment procedure is that the goal was never displayed; the intended goal of the actor had to be inferred by infants and recreated by them, although it was never presented to the senses.

These methodological and theoretical differences are actually productive for the field because they provide independent tests of infants' understanding using a variety of techniques. We can be more confident that infants are beginning to understand goals and intentions before language, inasmuch as the results from a variety of paradigms point in this direction. Moreover, the various procedures all point to an important developmental change in infants' reading of goals and intentions between about 9 and 15/18 months of age.

The goals of people: the motions of inanimate objects

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 present more borderline cases.) What do infants think?

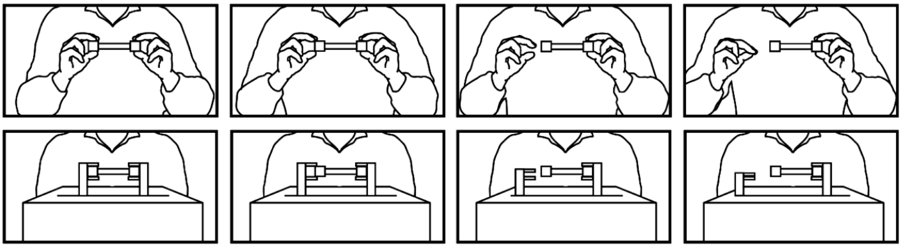

Figure 1.1 Human demonstrator (*top panel*) and inanimate device performing the movements (*bottom panel*) (from Meltzoff, 1995a)

To begin to examine this, Meltzoff (1995a) tested how 18-month-olds responded to a mechanical device that mimicked the same movements as the actor in the failed-attempt paradigm. 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 1.1, 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 in terms of a purely spatiotemporal description of movements in space.

The results showed that infants did not attribute a goal or intention to the movements of the inanimate device. Although they were not frightened by the device and looked at it as long as at the human display, they simply did not see the sequence of actions as implying a goal. Infants were no more (or less) likely to pull apart the toy after seeing the failed attempt of the inanimate device than in baseline conditions when they saw nothing.

Another study pursued this point. In this study the inanimate device succeeded. The inanimate device held the dumb-bell from the two ends and successfully pulled it apart. When infants were given the dumb-bell, they too pulled it apart. It thus appears that infants can pick up certain information from the inanimate device (they pull it apart after seeing the device do so), but they cannot pick up other information (concerning failed attempts).

I think 18-month-olds interpret the person's actions within a psychological framework that differentiates between the surface behavior of people and a deeper level involving goals and intentions. When they see a person's hands slip off the ends of the dumb-bell 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 dumb-bell, they see it as mechanical slippage and sliding with no implications for purposiveness.

It is possible that displays can be constructed that fool infants, as they do adults. Is a computer intentional? (*Mine* seems to know about grant deadlines and sabotage.) We do not know the necessary and sufficient conditions for ascribing intentions to entities. There is research, however, indicating that in certain circumstances infants see purposiveness in the actions of pretend humans (stuffed animals and puppets, Johnson, 2000) and dynamic displays that may be ambiguous as to animacy (e.g., some researchers have used 2-D spots that leap and move spontaneously on a TV screen: Gergely, ch. 2 this volume; Gergely, Nádasdy, Csibra, & Bíró, 1995).[2] This does not run against the thesis suggested here, but underscores the need for research on boundary conditions. The inanimate 3-D object used by Meltzoff (1995a) gives a lower boundary (infants fail) and real people give an upper boundary (infants succeed). There is a lot of room in between for more empirical research (and of course the conception of animate-inanimate changes with development, see Gelman & Opfer, ch. 7 this volume).

Human acts versus mechanical motions

On the basis of these findings it is useful to introduce a distinction that will be picked up later in the chapter. We wish to distinguish between construing the behaviors of others in purely physical versus psychological terms. To help keep this distinction clear we call the former motions and the latter human acts. The behavior of another person can be described using either physics or psychology. We can say, "Alison's hand contacted the cup, the cup fell over and the tea splattered" or "Alison was trying to pick up the cup (and disaster struck, as usual)." Strict behaviorists stick to the former description precisely because they eschew appealing to invisible psychological states. By 18 months old, infants are no longer behaviorists, if they ever were so. They do not construe the behavior of others simply as, "hold the dumb-bell and then remove one hand quickly" but rather construe it as an effort at pulling. Moreover, the work with the inanimate device shows that infants have a differentiation in the kinds of attributions they make to people versus things. By 18 months of age children have already adopted a fundamental aspect of a mature folk psychology – persons are understood within a framework involving goals and intentions.

Origins of Social Cognition: Toward Developing a New Theory

The problem

The puzzle of social cognition stems from the fact that persons are more than physical objects. Enumerating a person's height, weight, and eye color, does not exhaust our description of that person. We have skipped over their psychological makeup. If a self-mobile, human-looking body was devoid of psychological characteristics it would not be a person at all, but a robot or, to use the philosopher's favorite, a zombie. A fundamental issue is how we come to know others as persons like ourselves. Each of us has the phenomenological experience that we are not alone in the world, not the unique bearer of psychological properties. We know that we perceive, feel, and intend, and we believe others have psychological states just like ours.

Philosophers seek to justify the inference that the observed moving mounds of flesh are animated by psychological states. They contemplate whether this is a fiction and assemble criteria for knowing whether it is or is not (e.g., Russell, 1948; Ryle, 1949; Strawson, 1959). Developmental psychologists ask different questions. We inquire how such a view takes hold (regardless of whether it is logically justified). Is it innately specified? Does the child's understanding of mental states transform with age and social experience?

The starting-state: the primacy of human acts

The thesis of this chapter is that infant imitation provides an innate foundation for social cognition. Imitation indicates that newborns, at some level of processing no matter how primitive, can map actions of other people onto actions of their own body. When infants imitate they are linking the visual appearance of other people to their own internal kinesthetic feelings. They connect the visible bodily actions of others and their own internal states. Human acts are especially relevant to infants because they look like the infant feels himself to be and because they are events infants can intend. When a human act is shown to a newborn, it may provide the first recognition experience. "Lo! Something familiar! That seen event is like this felt event."

According to the thesis presented here, the starting-state parsing of the world by newborns is distinct from that proposed in other theories. The salient distinction for newborns is not the one between "animate versus inanimate" or "self-propelled versus moved-by-a-seen force." I would argue, instead, that the most salient distinction for newborns is the cut between "human acts versus other events" or possibly "acts that I can intend versus other events."

Privileged understanding of people

Infants' construing certain movements in the environment in terms of human acts that can be imitated has cascading developmental effects. First, the world of material objects is then divisible into those entities that perform these acts (people) and those that do not (things). Second, having made the division in the external world, new meanings are possible. Because human acts are seen in others and performed by the self, the infant can grasp that the other is at some level "like me." The other acts like me and I can act like the other. The crossmodal knowledge of what it feels like to do the act that was seen provides a privileged access to people not afforded by things. Newborns bring it to their first interactions with people, and it provides an interpretive framework for understanding the meaning that lies behind the perceived movements.

Using the "like me" analogy to attribute mental states to others

That young infants can interpret the acts of others in terms of their own acts and experiences provides them with enormous leverage and an engine for development. For example, the infant knows that when it wants something it reaches out and grasps it. The infant experiences her own internal desires and the concomitant bodily movements (hand extension, finger movements, etc.). The experience of grasping to satisfy desires gives infants leverage for making sense of the grasping behavior of others. When the child sees another person reaching for an object, she sees the person extending his hand in the same way, complete with finger curlings. Object-directed, grasping movements can be imbued with goal-directedness, because of the child's own experience with these acts.

One reason that such experienced-based "projection to others" has not been ascribed to the youngest infants is that classical theories thought them incapable of mapping their own manual movements to those they see others perform. After all, the child's hand is smaller than the adult's, seen from a different perspective, and so on. (Once again, the self and other seem to be known in such different ways.) But the research on imitation has established that young infants in the first half-year of life imitate manual gestures, including hand opening and closing (Meltzoff & Moore, 1997; Vinter, 1986). The data prove they can detect the similarity between their own manual movements and those they see adults perform. Self and other are known via a common code. A basic "like me" analogy may explain Woodward et al.'s (2001) fascinating findings that the amount of goal-directed reaching experience infants have predicts whether they succeed on tests evaluating their understanding of the reaches of others.

A similar argument applies to the goal-directed "striving" and "try and try again" behavior used in Meltzoff's (1995a) studies based on the behavioral re-enactment procedure. Infants have goals and act intentionally. They have experienced their own failed plans and unfulfilled intentions. Indeed in the second half-year of life they are obsessed with the success and failure of their plans: They mark such self-failures with special labels ("uh-oh," "no," or as once recorded in a British subject, "oh bugger" – see Gopnik & Meltzoff, 1986). More strikingly, they actually experiment with failed efforts by repeating the solution (and the failure) numerous times until it comes under voluntary control (Gopnik & Meltzoff, 1997; Gopnik, Meltzoff, & Kuhl, 1999b). During such episodes of testing plans and why they failed, infants often vary the means and "try and try again." When an infant sees another act in this same way, the infant's self-experience could suggest that there is a goal, plan, or intention beyond the surface behavior. Thus infants would come to read the adult's failed attempts, and the behavioral envelope in which they occur, as a pattern of "strivings," rather than ends in themselves.

Even understanding another's looking behavior could benefit from self-generated experience – in this case, experience of oneself as a looker/perceiver. Infants in the first year of life can imitate head movements and eye-blinking (Meltzoff, 1988a; Meltzoff & Moore, 1989; Piaget, 1962a). As unlikely as it seems at first, these data indicate that infants can map between the head movements they see others perform and their own head movements, and between adults' eyelid closures and their own eye closures. Infants' subjective experiences gained from "turning in order to see" could be used to make sense of the head movements of others who are orienting toward an object. Moreover, the infant's experience is that eye closure cuts off the infant's own perceptual access. If an infant can map the eye closures of others onto his own eye closures (something infants manifest in imitating blinking), these mappings may provide data for developing inferences about perception in others.

This also makes sense of the fact that young infants have more advanced understanding of eye-closure than obstacle-blocking (Brooks & Meltzoff, 2001). Certainly, 1-year-olds have had months of practice with voluntary looking away and eye-closing to cut off unwanted stimuli. This bodily act is well understood. However, it is only around this age that infants begin to play peek-a-boo and develop a facile manual search for occluded objects. Manual search for hidden things indicates an understanding of the relation between self, object, and occluder. Moreover, at about 12 to 14 months old infants first begin actively experimenting with this relation, as when they find and then repeatedly rehide objects from themselves, seemingly to master the problem (Moore & Meltzoff, 1999; Gopnik & Meltzoff, 1997; Gopnik, Meltzoff, & Kuhl, 1999b). One prediction is that intervention experience with occluders and the self could accelerate infants' understanding of blindfolds on other people.

Summary

Piaget (1952c) argued that the infant is born a "solipsist"; Fodor (1987) supposed that an innate theory of mind was hardwired into the human brain. Starting-state nativism offers a third perspective. It grants far more to the newborn than the first view, while stopping short of the second. My thesis is that a starting point for social cognition is that human acts are represented within a common code that applies to self as well as others. Newborns bring this representation of human acts to their very first interactions with people, and it provides an interpretive framework for understanding the behavior they see. Put succinctly, seeing others as "like me" is our birthright.

It has long been appealing to think that "like me" and the perception of self–other equivalences are vitally involved in adult social understanding. Empathy, role-taking, and all manner of putting yourself in someone else's shoes emotionally and cognitively seem to rest on the connection between self and other. The stumbling-block for classical theories was that the self–other equivalence was postulated to be late developing and therefore could not play a formative role. Nearly a quarter century of research on infant imitation stands this proposition on its head. It indicates that young infants can represent the acts of others and their own acts in commensurate terms. They can recognize crossmodal equivalences between the acts they see others perform and their own tactile-kinesthetic sense of self. *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 even the ingenious Mr. 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. We begin to "only connect" via a common code, a lingua franca, that does not depend on words. It is more fundamental than spoken language. This common code is the language of human acts.[3] The neuro-cognitive machinery of imitation lies at the origins of empathy and developing a theory of mind. Through understanding the acts of others, we come to know their souls.

Notes

1. Proponents of the arousal interpretation also argue that certain visual displays aside from tongue protrusion can elicit a tonguing response, and therefore that all imitation is due to arousal. But this argument is logically flawed. Suppose we wanted to show that school-age children can imitate the act of hand raising. They do so after seeing us; this is imitation. But they also may raise their hands in other circumstances and in response to other stimuli. For example, they may raise their hands when they have a question to ask. They may also do so when we give them a verbal command to "raise your hand." They may also do so when they want to change an overhead light bulb. As in many experiments in psychology, the claim that a stimulus (adult tongue protrusion) elicits a response (infant tongue protrusion) is not a statement that no other stimulus does so. A sufficient cause is not a necessary cause. The control conditions that Meltzoff and Moore used distinguish imitation versus arousal. Moreover, the factors in table 1.1 go far beyond the mere existence of infant tonguing; they strengthen the interpretation of imitation and have been left wholly unaddressed by proponents of arousal.
2. Gergely et al. (1995) can be interpreted as showing that 12-month-olds attribute primitive goal-directedness to inanimate objects. However, there are differences between this research and the Meltzoff studies, so there is no contradiction involved. The "goals" in the Gergely et al. work are spatial locations, physical endpoints (such as "next to the small object" or "in the left-hand corner of the screen"), see Gergely, ch. 2 this volume, for details. The reenactment procedure measures the child's inferences about complex human actions on objects, such as striving to pull an object apart. It is possible that infants reason about spatial paths and *seen* goals (as in the Gergely experiments) before they can make inferences about endpoints that are never achieved, and therefore *un*seen, as in Meltzoff's failed-attempt experiments (for a more extensive discussion about infants' reasoning about spatial trajectories and versus seen unseen events, see Meltzoff & Moore, 1998b).
3. If correct, species with more general imitative capacities (motor, face, hands, vocal) in infancy should develop more sophisticated forms of social cognition (Meltzoff, 1996a). And conversely, atypical infants lacking imitative capacities and the sense that others are "like me," for example children with autism (e.g., Dawson, Meltzoff, Osterling, & Rinaldi, 1998; Dawson, Carver, Meltzoff, Panagiotides, & McPartland, in press; Meltzoff & Gopnik, 1993), will not come to understand the minds of others.