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CHAPTER 9

Intersubjectivity before language

Three windows on preverbal sharing

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There has been a revolution in our understanding of intersubjectivity. This revolution has many roots. Three findings of special interest are represented in the present volume: (a) the landmark work on *preverbal intersubjectivity* by Trevarthen (1979), Trevarthen and Hubley (1978), Stern (1985), and Bråten (1998a, 2003); (b) the findings of *neonatal imitation*, which demonstrates a social connectedness that is literally present at birth (e.g., Heimann 2002; Kugiumutzakis 1998; Meltzoff 2006; Meltzoff & Moore 1983, 1997); and (c) advances in neuroscience, particularly the report of a *mirror neuron system* (e.g., Gallese 2003, 2005; Iacoboni, Woods, Brass, Bekkering, Mazziotta, & Rizzolatti 1999; Jackson, Meltzoff, & Decety 2006; Rizzolatti, Fadiga, Fogassi, & Gallese 2002; Rizzolatti 2005). All three suggest a close coupling between self and other with profound implications for shared emotions (e.g., Hobson 2002; Hobson & Meyer 2005; Meltzoff 2007; Rochat & Striano 1999; Tomasello 1999).

The revolution did not occur at the dead of night, but was well discussed. For example, there has been (a) a discussion of the relevance of the new findings for clinical psychology in a special issue of the *Psychoanalytic Dialogues* (Beebe, Sorter, Rustin, & Knoblauch 2003), (b) a special issue of the *Philosophical Transactions of the Royal Society*: *Biological Sciences* concerning social neuroscience (Frith & Wolpert 2003), and (c) several edited books in the past 5 years examining the implications of infant intersubjectivity for topics ranging from artificial intelligence to sociology (Nehaniv & Dautenhahn 2007; Hurley & Chater 2005; Meltzoff & Prinz 2002; the current volume).

The myth of the asocial infant

The intellectual ferment derives in large measure from the fact that, within our lifetimes, we have witnessed the overturning of one of the most pervasive myths in social science – the myth of the asocial infant. 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 an interpersonal birth (Freud 1911; Mahler, Pine, & Bergman 1975). The baby is like an unhatched chick, incapable of interacting as a social being because a 'barrier' leaves the newborn cut off from external reality. Freud struggles to find a metaphor for the newborn-parent relationship and ended up likening the child's situation to the isolation found inside a shell: "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: 220).

Piaget's (1952, 1954) newborn is similar, but he uses a philosophical rather than biological metaphor. He believed that the baby is 'radically egocentric' or even 'solipsistic.' The neonate has only a few reflexes at her disposal (e.g., sucking, grasping), and people are registered only to the extent that they can be assimilated to these action schemes. The child breaks free of the inborn solipsism by 18 months. It is a very long and hard journey from solipsism to establishing intersubjective understanding of others' minds and emotions: "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: 352–355).

Skinner (1953) claimed that the newborn had even less to work with. One cannot quote from Skinner about how children come to feel a sense of intersubjectivity with others, because, in a sense, he does not think they ever do. Even adults are described as reacting to behaviours and not to participating in the hearts and minds of their interactive partners. Human beings have exquisite contingency detectors, and that is all there is. To use Skinner's phrase, intersubjectivity is largely a 'matter of consequences' (Skinner 1983), by which he means that people are important only as shapers of the child's behaviour. In theory, a Skinner box would do just as well as a mother's embrace if the contingencies were programmed correctly.

Against all three of these views are precursors to the modern-day findings of an innate intersubjectivity. Philosophers such as Husserl (1950/1960) and Merleau-Ponty (1945/1962) and psychologists such as Baldwin (1906) and Mead (1934) refused to portray the human from an 'isolationist' perspective and saw a deep connection between self and other. Modern-day findings support and elaborate the ideas of these pioneers (see Gallagher & Meltzoff 1996 for an analysis of

Merleau-Ponty's points on intersubjectivity in light of recent psychological findings).

Our journey in this chapter

In this chapter we wish to discuss three phenomena that illuminate the nature of preverbal intersubjectivity: (a) action imitation, (b) joint visual attention, and (c) sensitivity to intentionality. These phenomena make manifest the intrinsic bonds infants have with social others. Bråten (2004) calls it 'participant perception' and Hobson (Hobson & Lee 1999; Hobson & Meyer 2005) discusses 'identification' – but, regardless of the label, the convergent point is that infants respond to the actions of people in special ways revealing a desire for sharing in their experiences. We discuss three kinds of social sharing that are interconnected developmentally and philosophically.

First we discuss imitation, which shows a sharing of actions. This action sharing is literally present at birth and tells us much about the intersubjectivity that infants bring to their first encounters with embodied others. Second, we discuss joint visual attention. A momentous development in the first year is the onset of gaze following. Infants begin to turn to look at another's target of attention. They seem to want to share the viewpoint of others, to have the same perceptual experience of others, with important implications for emotions and language. Third, we discuss experiments showing that in the second year of life infants have a growing sense of intentionality. They respond to the unfulfilled goals and intentions of others – what people *mean* to do, not simply what they *actually* do. People are intentional agents and as such are not always to be taken literally.

A principal purpose of this chapter is to show that Seattle's laboratory research, which is sometimes misinterpreted as exclusively cognitive in nature, actually provides three windows onto the nature and development of infant intersubjectivity. By coupling experimental work and theorizing we can get a fuller picture not only of infants' initial state but also of the mechanisms of change in socio-emotional development (Meltzoff 2007; Repacholi & Meltzoff in press).

Sharing others' actions: Newborn imitation

Background and significance

Being caught up in others' movements, imitating what you see, is an essential aspect of human intersubjectivity. Although other primates learn from observation, they are more proficient at adopting the outcomes/results than in duplicating the

means and mannerisms we use to achieve these results (Meltzoff 1996; Povinelli 2000; Tomasello & Call 1997; Williamson & Markman 2006; Whiten 2002). Action imitation is also impaired in children with autism (e.g., Dawson, Meltzoff, Osterling, & Rinaldi 1998; Hobson & Lee 1999; Hobson & Meyer 2005; Meyer & Hobson 2005; Rogers 1999; Toth, Munson, Meltzoff, & Dawson 2006; Whiten & Brown 1998).

The imitation of simple body actions is sometimes dismissed as 'mere mimicry,' and this language has caused generations of psychologists to miss its essence and importance. Such action imitation is important for building social rapport and the maintenance of caring communication. It is well-known that body mirroring occurs between patient and therapist in successful psychotherapy sessions (Beebe, Rustin, Sorter, & Knoblauch 2003). Similarly, many of the customs, rituals, greetings, and everyday emotional exchanges revolve around acts of reciprocal imitation. The duplication of the action patterns, mannerisms, and gestures others use is part of the fabric of human communication. It runs in the background and fosters emotional cohesion in everyday interactions, oftentimes outside of explicit awareness (Bargh & Chartrand 1999; Chartrand & Bargh 1999; for related brain imagining work, see Decety, Chaminade, Grèzes, & Meltzoff 2002).

Data and theory

Meltzoff and Moore (1983, 1989) reported that newborns imitate facial acts. The mean age of these infants was 36 hours old. The youngest child was 42 minutes old at the time of test. Newborn facial imitation suggests an innate mapping between observation and execution in the human case. Moreover, the studies provide information about the nature of the machinery infants use to connect observation and execution.

It is important to realize that this is genuine imitation and not simply a diffuse arousal response, which would have far fewer implications for intersubjectivity and neuroscience. Meltzoff and Moore (1977) demonstrated that 12- to 21-day-olds didn't confuse either actions or body parts. They differentially responded to tongue protrusion with tongue protrusion and not lip protrusion, showing that the specific body part can be identified. They also differentially responded to lip protrusion versus lip opening, showing that differential action patterns can be imitated with the same body part. This was extended by research showing that infants differentially imitate two different kinds of movements with the tongue (Meltzoff & Moore 1994, 1997). In all, there are 30 studies of early imitation from more than a dozen independent laboratories across a range of gestures (see Meltzoff & Moore 1997 for a systematic review). To be sure, there is development in imitation, for example the neonate is less self-conscious about imitating than the toddler

(Meltzoff & Moore 1997), but the evidence clearly shows that human infants are born imitating.

The nature of the imitative response is informative for theories. First, many labs have reported that infants do not imitate the social other immediately (Heimann 1998, 2002; Kugiumutzakis 1998; Meltzoff & Moore 1994, 1997). The infant's first response to seeing a facial gesture is activation of the corresponding body part. For example, when infants see tongue protrusion, there is a quieting of other body parts and an activation of the tongue. They do not necessarily protrude the tongue at first, but may elevate it or move it slightly in the oral cavity. The important point is that the tongue, rather than the lips or fingers, is energized before the movement is isolated. Meltzoff and Moore (1997) call this 'organ identification.' Neurophysiological data show that visual displays of parts of the face and hands activate specific brain sites in monkeys (Desimone 1991; Gross 1992; Gross & Sergent 1992; Jellema, Baker, Oram, & Perrett 2002; Perrett, Hietanen, Oram, & Benson 1992) and related work is emerging in human studies (Buccino et al. 2001). Specific body parts could be neurally represented at birth and serve as a foundation for infant imitation. An embryonic body scheme is drawn on in imitation (Gallagher & Meltzoff 1996).

AIM hypothesis. Meltzoff and Moore proposed that early facial imitation is based on active intermodal mapping (AIM) (Meltzoff & Moore 1977, 1997). This is not a complex mechanism that requires cognitive machinations by the infant. The principal claim is that imitation is a matching-to-target process. The active nature of the matching process is captured by the proprioceptive feedback loop. The loop allows infants' motor performance to be compared against the seen target and serves as a basis for infants' correcting the response and homing in on the target act. AIM proposes that such comparison is possible because the observation and execution of human acts are coded within a common framework. We call it a 'supramodal' act space, because it is not restricted to modality-specific information (visual, tactile, motor, etc.). Metaphorically, we can say that exteroception (perception of others) and proprioception (perception of self) speak the same language; there is no need for associating the two through prolonged learning because they are bound together at birth. A more detailed analysis of the metric of equivalence between acts of self and other is provided elsewhere (Meltzoff 2006; Meltzoff & Moore 1997).

This hypothesis of a supramodal framework for coding of acts that emerged from developmental psychology nearly 30 years ago fits well with modern proposals from cognitive science (Prinz 2002, 2005) and neuroscience (Decety 2002; Iacoboni et al. 1999; Rizzolatti, Fogassi, & Gallese 2001). Some effort is being made to analyze the commonalities and differences in the models proposed from these different fields (Gallese 2003; Meltzoff & Decety 2003; Rizzolatti et al. 2002). But

even at this time, we can say that they all converge on the idea of a close coupling between perception and action that undergirds intersubjective engagement with others. The unique contribution from developmental science is that newborn imitation demonstrates that self-other connectedness is functional at birth in the human case. Imitation is a marker of innate intersubjectivity in action.

Sharing others' attention

Background and significance

The blissful state of dyadic interaction does not last for long. Soon there are interlopers as the infant becomes aware that third parties are vying for mother's affection. For example, infants begin to pay attention to the fact that mothers do not always look at them, but also cast their gaze to external objects, siblings, and spouses in the environment. One measure of this dawning realization is infants' gaze following, that is, their tendency to follow mother's gaze to an external target in order to see what she is looking at. This is not the duplication of exact bodily movement, but rather a taking into account that her behaviour is directed toward an external target.

Gaze following is the leading edge of what some refer to as 'secondary intersubjectivity' (Bråten 1998b, 2003; Trevarthen & Hubley 1978) and others call 'triadic' communication (Bakeman & Adamson 1984; Hobson, Patrick, Crandell, García-Pérez, & Lee 2004). Through gaze following there is the creation of a preverbal referential triangle – mother-baby-object – in which the mother's visual glances refer infants to selected external targets. Among adults, detecting the direction of another's gaze is a crucial component of social interactions (Argyle & Cook 1976; Kleinke 1986; Langton, Watt, & Bruce 2000).

The onset of gaze following has profound implications both for language and emotions. It is relevant for understanding the meaning of an emotional display, because a person's emotion is often engendered by what he or she sees in the external world (e.g., that object is appealing or disgusting). By following your partner's gaze you can grasp the cause of her emotional display (Moses, Baldwin, Rosicky, & Tidball 2001; Repacholi 1998; Repacholi & Meltzoff in press). Language acquisition is also facilitated by understanding another's line of regard. In the prototypical case, a verbal label refers to the object being looked at, and not the other objects in the room. Individual infants who follow mother's gaze may be given a boost in language learning (Baldwin 1995; Brooks & Meltzoff 2005; Morales, Mundy, & Rojas 1998; Mundy, Fox, & Card 2003; Carpenter, Nagell, & Tomasello 1998). Beyond all this, some, like Ginger Rogers, would argue that gaze following is an intersub-

jective act that allows us to take the perspective of another: "When two people love each other, they don't look at each other, they look in the same direction."

It is well established that young typically developing infants turn in the direction that an adult has turned, but there is a debate about the underlying mechanism and developmental time course (Butterworth 2001; Moore & Dunham 1995). One conservative proposal suggests that following where another looks has nothing to do with intersubjective sharing. On this view, the behaviour is based on infants' visually tracking the adult's head movements because the head produces salient/large displacements in the visual field. Inasmuch as infants visually follow head movements, they are automatically 'dragged' to the correct half of space. Once in the correct hemi-field they latch onto whatever attractive object is there, usually the same one at which the adult is looking. On this account, infants are *not* responding intersubjectively and are simply processing physical movements in space caused by the head, regardless of what the eyes, are doing. They would be just as likely to follow the movements of an inanimate object.

Data and theory

We developed a test procedure that zeroed in on the importance of eyes in infant gaze following (Brooks & Meltzoff 2002, 2005). In this procedure, an adult turned to look at one of two targets. The principal 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, they should turn in both cases. If, however, infants appreciate that the eyes are relevant for connecting a 'perceiver' and object, then they should differentiate the two conditions and turn to look at the target in one situation and not the other. The reason such a manipulation is crucial for theory is that we do, in fact, see with our eyes and not with our head. It is an important step forward in intersubjective understanding for infants to put special emphasis on eyes. It is, after all, the eyes that are the 'window to the soul' – the head is not such a portal.

Brooks and Meltzoff (2002) used the Gaze Following: Eyes Open/Closed test to assess 12, 14, and 18-month-old infants. Each infant at each age was randomly assigned to a condition in which the adult turned to the target with either open or closed eyes. The targets were silent 3-D toys placed equidistant from the infant and the adult turned to the objects on four separate trials (two to the left and two to the right) for each infant.

The main findings are depicted in Figure 1. As shown, infants carefully observed the adult and followed the adult's gaze to its terminus in the object (Fig. 1a). Infants at all three ages followed the adult significantly more often when the adult turned with open than closed eyes (Fig. 1b). We also scored three behaviours beyond the traditional measure of where the infant looked. First, we scored in-

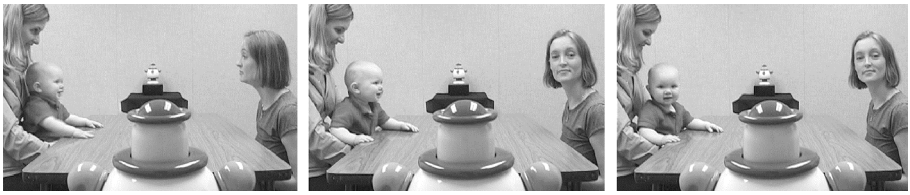

Figure 1a. An infant and adult make eye contact, the adult turns to look at the target, and the infant follows and looks at the correct target.

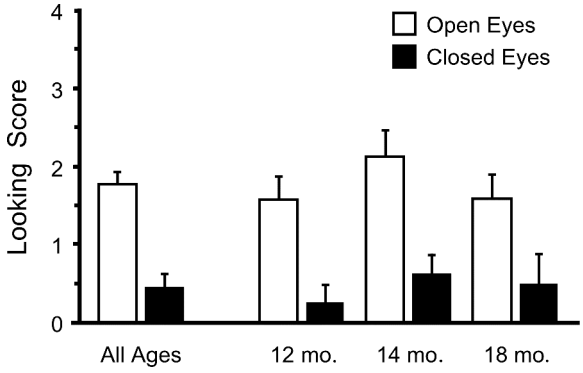

Figure 1b. The looking score is a total of correct looks, incorrect looks and 'non-looks.' Thus, when an infant looks at correct targets, she receives a higher total score; however, if she looks at incorrect targets, she lowers her total score. Infants look at the correct target more often in the open-eyes than the closed-eyes condition. Adapted from Brooks and Meltzoff (2002).

fants' average duration of correct looks. This revealed that infants inspected the target for a longer duration when the adult turned to it with open versus closed eyes. Second, analysis of infant vocalizations showed that they vocalized more toward the correct target in the open-eyes as opposed to closed-eyes condition. Third, significantly more infants pointed to the targets in the open-eyes condition than in the closed-eyes condition (Figure 2). This latter behaviour is particularly striking because it is ostensive – the results show that infants are taking into account the perceptual status of the audience. Infants point when the social partner can see the objects but refrain when the partner cannot (eyes closed), which Brooks and Meltzoff (2002) interpreted as 'proto-declarative' pointing (see also: Bates, Benigni, Bretherton, Camaioni, & Volterra 1979; Camaioni, Perucchini, Bellagamba, & Colonnesi 2004; Franco & Butterworth 1996; Liszkowski, Carpenter, Henning, Striano, & Tomasello 2005).

We return now to the rationale for conducting this study. The non-social interpretation of gaze following is that a visible movement simply drags infants'

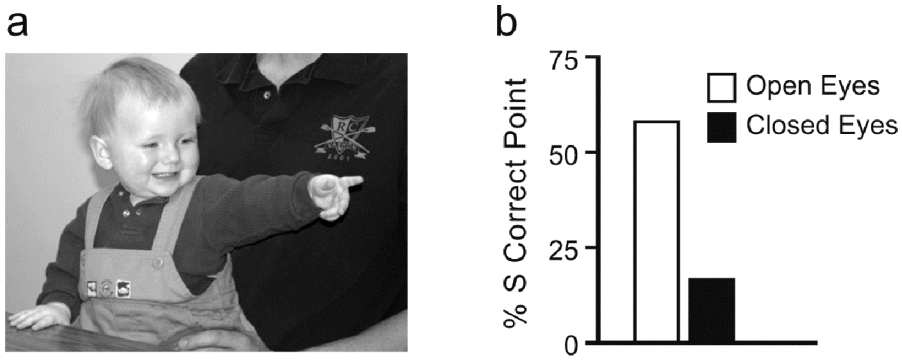

Figure 2. (a) A 12-month-old boy points at the target. (b) Infants selectively point to the target when the adult has her eyes open rather than closed. This suggests that points are used to share with others in a 'proto-declarative' manner and not produced solipsistically.

attention to a hemifield of space where they happen to see an interesting object. The current findings disprove this interpretation, because head movement was controlled, and show that infants were more likely to look at the correct target when the social partner can see it. We also discovered that the inanimate object takes on a special valence when it is looked at by a social other (i.e., it attracts looks of longer duration). It is as if having the adult shine her social spotlight on an inanimate object leaves a trace on it, an invisible mark. Such is the power of intersubjectivity – being 'visually touched' by a social other transforms the object from a boring blob to an object of desire that cries out 'Look at me!'

Developmental shift – Roots of secondary intersubjectivity. When does gaze following begin? Brooks and Meltzoff (2005) conducted a study of infants during a period of developmental transition, from 9 months to 11 months of age (Bates et al. 1979; Bråten 2003; Carpenter et al. 1998; Trevarthen 1979). The infants were recruited to fall at three discrete ages: 9, 10, and 11 months old, with each infant ± 1 week of the target age, which allowed careful monitoring of the shift to secondary intersubjectivity.

The same Gaze Following: Eyes Open/Closed test was used. The results showed that the 9-month-olds did *not* discriminate between the open- versus closed-eyes conditions. They turned equally often in both cases. However, there was a clear developmental shift 30 days later. For 10-month-olds, the looking scores in the open-eyes condition were significantly greater than in the closed-eyes condition; and 11-month-olds did the same. This sharp change leads us to wonder about possible neurological underpinnings. By about 10 months of age infants begin to understand others as 'visually connected' to the external world and that the

eyes are the critical organ. This is an important step in secondary intersubjectivity because the infant is coming to regard eyes as special.

Psychology versus physics: The eyelid-blindfold distinction. There is a further important development that occurs at about 12 months of age. Eye closure is only one way to block a person's line of sight. Another way is to use an inanimate object. From an adult perspective, an opaque physical barrier has the same function as closed eyes – both prevent visual access. Our results suggest that infants understand the consequences of eye closure (a biological motion) before they understand blindfolds (an inanimate barrier). This is fascinating because it opens the possibility that infants' reactions to an intersubjective other are richer, deeper, and in some cases more advanced than their reactions and understanding of inanimate things.

In the study of inanimate occluders, the person turned toward a target wearing either a headband or a blindfold (Brooks & Meltzoff 2002; Experiment 2). In both instances, the same cloth covered part of the experimenter's face, but in one situation the opaque cloth was on the forehead and in the other it was over the eyes. We tested 12-, 14- and 18-month-old infants using the same room set-up as in eyes open/closed studies. If infants were flummoxed by the novelty of the opaque cloth, they would stare at the adult and not look at the targets in either condition. If infants are simply following head turns, they would look at the external target but do so indiscriminatingly in both conditions. If infants recognize that a blindfold blocks visual access but headbands do not, they would look significantly more often at targets indicated by an adult wearing a headband compared to a blindfold. The results showed that 14- and 18-month-old infants looked at the adult's target significantly more often in the headband than the blindfold condition. In contrast, the 12-month-olds infants did not distinguish between the two conditions. They systematically looked at the indicated target whether the adult turned wearing the blindfold or the headband.

These findings are interesting, especially when compared to the eyes open/closed test. Recall that the 12-month-olds had succeeded admirably on the eyes closed/open test. Yet when the adult's vision was blocked by an inanimate object (blindfolds), they did not. This is not just a matter of blindfolds causing a general suppression of activity. Rather, infants make the mistake of following the 'gaze' of the adult wearing the blindfold. In other words, they acted like the 9-month-olds did in the closed-eyes case. It is as if they recognize that the human act of eye-closure blocks contact with external objects, but do not yet understand the same about inanimate occluders.

'Like me' and 'like you': The importance of shared experiences

Background and significance

The foregoing research indicates that at least one kind of occluder to vision, eye closure, is understood quite early. One hypothesis is that this is because infants themselves have ample prior *intra*subjective experience with the perceptual effects of eye closure. When they do so, the world goes black. They may be able to use this experience to imbue the eye closures of others with meaning. If true, the non-biological occluders should become more meaningful as a block to others' perception if infants are themselves given opportunities to learn that they block their own vision.

Data and theory

Meltzoff and Brooks (2004) gave 12-month-olds experience that blindfolds lead to psychological effects – that the infants themselves cannot see through a blindfold. Infants were randomly assigned to a baseline condition or two treatment groups, one of which involved blindfolds and the other involved the same black cloth but with a 'peeking window' cut out of the middle. The infants experienced that the blindfold blocked their view. Their perception of the world was blocked when the blindfold was held in front of *their* eyes, and was restored again when the blindfold was removed. This *intra*subjective experience had nothing to do with the experimenter's viewpoint; it was a first-person experience. In the critical test, the adult put the blindfold over her own eyes. This was the first time the infants were presented with the blindfolded adult.

The results showed that infants now appreciated the consequences of blindfolds for the other. They did not turn when the adult wore the blindfold. In the control groups (baseline and cloth with peeking window) the infants were allowed to familiarize themselves with the cloth, but without the perceptual experience of a loss of vision. These two experiences had no effect on how they treated the other. As we expected, the control-group infants still mistakenly followed the blindfolded adult's 'gaze.'

This is the first study showing that infants use first-person experience about a mental state such as "seeing" to grasp the experience of others. We believe that first-person experience with blindfolds changes infants' appreciation of the other's situation. These effects provide a nice demonstration of a 'like me'/'like you' interpersonal mechanism at work. This mechanism and its philosophical and developmental implications are elaborated in more detail elsewhere (Meltzoff 2006, 2007).

The relation between gaze following and language acquisition

Background and significance

On theoretical grounds, there is good reason for thinking that secondary intersubjectivity embodied in gaze following may be an important component of language acquisition. Infants who understand adult gaze as an ostensive act are in a better position to use everyday interactions with adults to learn words as labels for external objects (e.g., Baldwin & Moses 2001; Bruner 1983; Meltzoff & Brooks 2006; Tomasello 2003). Not all language refers to tangible entities that can be looked at (Gopnik 1982, 1988; Gopnik & Meltzoff 1986). Nonetheless one basic format in the "initial word learning game" (Bruner 1983) is for parents to point out salient objects through gaze and then to label them. Infants who are advanced on gaze following in particular (and perhaps in understanding referential intent in general), may have a leg up on learning language (Tomasello, Carpenter, Call, Behne, & Moll 2005). In order to pursue this idea within our own data set we conducted a longitudinal follow-up of the children who came into the lab at 10–11 months of age – the infants we caught right at the onset of gaze following.

Data and theory

Brooks and Meltzoff (2005) assessed whether gaze-following behaviour at 10–11 months predicted later language development. Language development was assessed with the MacArthur-Bates Communicative Developmental Inventory (CDI) (Fenson, Dale, Reznick, Bates, Thal, & Pethick 1994). The results showed that gaze-following behaviour at 10–11 months predicted language development over 1 year later. This was powerfully demonstrated by the relationship between the average duration of looking to the correct target at 10–11 months and subsequent language. During the follow-up test at 2 years of age, this infant gaze-following score at 10–11 months predicted a significantly larger productive vocabulary size ($r = .63$, $p < .01$) and sentence complexity ($r = 57$, $p < .05$). For example, infants who had previously had poor gaze-following scores one year earlier produced utterances that included structures such as "want more" or "cars voom." In contrast, infants who had high scores had sentences that included, "Sit right down here mommy, legs out, and play with spinning tops."

This research supports the proposition that intersubjectivity and language learning are deeply connected (e.g., Bråten 2003; Rommetveit 1998). The current findings complement other empirical reports that infant gaze following predicts language development (Carpenter et al. 1998; Heimann, Strid, Smith, Tjus, Ulvund & Meltzoff 2006; Morales, Mundy, Delgado, Yale, Messinger, Neal, & Schwartz 2000; Mundy et al. 2003).

Sharing others' goals and intentions

Background and significance

In mature adult social cognition, I not only share behavioural actions and line of regard with others, but I also share in their goals and unspoken intentions. 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 intention in performing these actions. Wittgenstein (1953) clarifies this distinction with this pithy insight: 'What is left over if I subtract the fact that my arm goes up from the fact that I raise my arm?' Answer: 'Intention.'

Is there any evidence that infants have a feel for human action that penetrates below the surface behaviour to the intentions that lay behind them? To address these questions, it is not enough to explore whether young children act intentionally themselves; we need to investigate whether they appreciate the intentions and goals of others.

Data and theory

Seeing goals in others' actions. The 'behavioural re-enactment procedure' was created to investigate infants' reactions to the goals and intentions of others (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 behaviour to something like the goal or intention of the actor. The 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. Adults immediately sense the actor's intentions although he never fulfills them. The question is whether children see beyond the literal body movements to the goal or intention of the act. In a sense, the 'correct answer' is to not copy the literal movement, but the intended act that remains unfulfilled and invisible.

Meltzoff (1995) showed 18-month-old infants an unsuccessful act. 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 'see through' the surface behaviour to the underlying

goals or intentions of the actor. Evidently, toddlers can understand our goals even if we fail to fulfill them.

Seeking social help. In further work, 18-month-olds were shown similar displays, but were handed a trick toy that prevented them from performing the intervention (Meltzoff 2006). For example, the dumbbell-shaped object was surreptitiously glued shut. If infants attempted to pull it apart, their hands slipped off the ends, duplicating the adult's behaviour. The question was whether this satisfied infants. It did not. They varied the way they yanked on the dumbbell, systematically changing their strategies to find one that worked. They also appealed to their mothers and the adult for help. About 90% of the infants looked up at an adult within 2-sec after failing to pull apart the trick toy and many vocalized while staring at the adult's face. Why were they appealing for help from the social other? They had matched the adult's surface behaviour, but evidently they were striving toward something else – the adult's intended goals. This fits with Meltzoff's (1995) hypothesis that infants had grasped the goal of the act, clearly differentiating it from the literal surface behaviour that was observed.

The goals of people; the motions of machines. In the adult framework, only certain types of entities are ascribed to intention and purposiveness. Chairs and boulders rock and 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. What do infants think?

To begin to examine this, Meltzoff (1995) tested how 18-month-olds responded to a mechanical device that mimicked the same movements as the actor in the failed-attempt condition. 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 (Fig. 3, 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

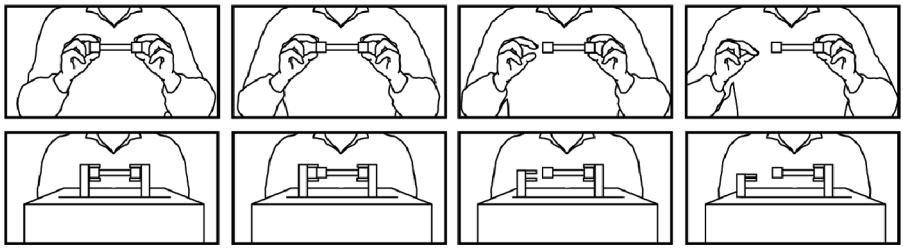

Figure 3. Human demonstrator (top panel) and inanimate device mimicking these movements (bottom panel) (from Meltzoff 1995).

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 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.

We think 18-month-olds cast the person's actions within an intersubjective framework that differentiates between the visible behaviour and a deeper level of felt experience involving human goals and intentions. When they watch a person's hands slip off the ends of the dumbbell they immediately see what the adult was 'trying' to do. When they see the inanimate device slip off the end of the dumbbell, they see it as mere mechanical slippage with no implications for purposiveness.[1] The appreciation of others' goals and intentions is intersubjectivity in action.

Conclusions. The centrality of preverbial intersubjectivity

Posing the problem

According to classical developmental theory, from Freud to Piaget, newborns lack any inkling that other humans have psychological properties. They did not appreciate that humans are 'subjects' different from the 'objects' in the environment. It was claimed, for example, that the child is born a solipsist (Piaget 1954) or is in a state of 'normal autism' (Mahler et al. 1975), treating people the same as things. Philosophers have argued for centuries about the initial state of human beings, but in the modern era, three constraints have been put on the debate (see also Gallagher 2001, 2004; Goldman 2005; Gordon 2005).

First theorists have begun to take seriously the developmental question: 'how can we get here from there.' *If* it were true that we are born solipsistic or autistic, what sort of experiences could ever get us to the rich state of empathy and shared emotions for our fellow humans that we all experience as adults (Jackson, Brunet, Meltzoff, & Decety 2006)? No one has been able to provide an adequate learning account. Second, the relevant selective-rearing experiments have been done. There is no evidence that home-reared chimpanzees or children with autism who undergo extensive intervention programs develop the intrinsic feelings of intersubjectivity that is felt by typical adults. Thus, without a certain biological endowment, it does not appear that intersubjectivity can be created by cultural emersion. Intersubjectivity is a precondition for culture not the outcome of it.

Third, experiments with human infants belie the premise of infantile solipsism. We have accumulated massive evidence not only for preverbal intersubjectivity, but for innate intersubjectivity.

Mirror neurons

Before returning to the behavioural examples of imitation, joint visual attention, and intention, it is worth considering the recent breakthroughs in cognitive neuroscience, which offer complementary findings to those discussed here. There is an explosive growth in the neuroscience literature concerning the equivalent coding for actions of self and other. Mirror neurons are perhaps the most celebrated example. There are ample reviews of mirror neurons elsewhere in this volume. Here we only focus on one often-ignored question – the Developmental Question. Are mirror neurons innate?

This is a thorny problem, and the role of experience in forming mirror neurons has not been fully examined. Mirror neurons are activated whether a monkey observers or executes an act such as grasping an object (e.g., Gallese 2003; Rizzolatti, Fadiga, Gallese, & Fogassi 1996; Rizzolatti 2005). However, adult monkeys have repeatedly watched themselves grasping objects. Mirror neurons could code visuomotor associations forged from such learning experiences (the same for auditory mirror neurons that fire when an action such as tearing is seen or heard). Such gradual learning, if it occurs, would deeply impact the philosophical implications that can be drawn.

This is where is where bringing together developmental science and neuroscience can be especially informative (Meltzoff & Decety 2003). Developmentalists would suggest that there are two ways of testing whether mirror neurons develop through experience. One is to test newborn monkeys, just as we have tested newborn infants only minutes old, before they have had a chance to forge the associations in question. A second approach is selective rearing in which the experimenter arranges a situation that prevents monkeys from visually monitoring their own grasps, for example, by wearing a collar that blocks the view of their hands. The critical question for theory is whether mirror neurons can be found in the brains of such animals. If both populations have functioning mirror neurons, it would suggest that mirror neurons do not emerge from learned associations of repeatedly seeing oneself grasp an object. At this juncture we simply don't know whether mirror neurons are the result of experience or are brought to experience.

Innate human intersubjectivity

The philosopher's queries about man's original nature are not definitively answered by tests of adults (whether monkey or man). These need to be supple-

mented with tests of newborns. Facial imitation provides such an opportunity. Human infants have a natural collar; they cannot see their own faces. If they are young enough, they will never have had a chance to see themselves in a mirror or to learn the associations in question. Neonatal facial imitation provides a direct test of whether the observation and execution of action are closely knitted together *prior to* associative experience. The results show that the observation and execution of actions are intrinsically intertwined in the human case.

Newborn imitation indicates that, at some level of processing no matter how primitive, infants can map actions of other people onto actions of their own body. Because human acts are seen in others and performed by the self, the infant can grasp that the interpersonal connection: You can act 'like me' and I can act 'like you,' which Meltzoff (2006, 2007) describes as the 'Like Me' bridge. This self-other equivalence provides a privileged access to people not afforded by things. It provides a framework of sharing and communication.

It has long been thought that the equivalence between self and other is integral to our adult commonsense psychology (Husserl 1950/1960; Mead 1934; Smith 1759/1976). Empathy, perspective-taking, and all varieties of putting yourself in someone else's shoes emotionally seem to depend on this. The problem has always been that this equivalence was thought to be a late achievement in ontogeny, possibly dependent on language. The findings from developmental science, suggest that infants already register the equivalence between acts of self and other. It is not a derived, complex, or cognitively advanced analysis of the world. There is an intrinsic relation to others that infants feel preverbally. This 'felt connection' colours infants' very first interactions and interpretations of the social world and is foundational for human communication and development.

A mechanism of change for enriching intersubjectivity

That young infants can interpret the acts of self and other within the same framework provides them with enormous leverage and an engine for interpersonal development. For example, the infant knows that when she wants something she 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 'feeling with' the other who grasps for things. When the child sees another person reaching for an object, she sees the person extending his hand in the same way. These movements are imbued with experiential meaning, in part because of the child's own experience with these acts.

A similar argument applies to the goal-directed 'striving' and 'try and try again' behaviour in Meltzoff's (1995) studies using the behavioural re-enactment procedure. Infants have subjective desires and act intentionally. They have experi-

enced their own thwarted desires, 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 verbal labels such as "uh-oh," "no," or as recorded in a British child, "oh bugger" (Gopnik & Meltzoff 1986). More strikingly, they actually play with failed efforts by repeating the solution (and the failure) numerous times until the solution comes under voluntary control (Gopnik & Meltzoff 1997; Gopnik, Meltzoff, & Kuhl 1999; Moore & Meltzoff 2004). During such episodes of testing why they failed, infants often vary their strategies and 'try and try again.' This *intra*subjective exploration deepens their *inter*subjective grasp about the motivation and meaning of others' behaviour. Specifically, when an infant sees another act in this same way, the infant's self-experience could suggest that there is a purpose, desire, or intention beyond the surface behaviour. Thus infants would see the adult's failed attempts, and the behavioural envelope in which they occur, as a pattern of 'strivings' rather than ends in themselves.

Gaze following admits to a similar theoretical analysis. The understanding of another's looking behaviour could benefit from *intra*subjective experiences – in this case, experience of oneself as a perceiver. Infants in the first year of life can imitate head movements and eye blinking (Meltzoff 1988; Meltzoff & Moore 1989; Piaget 1962). As unlikely as it seems at first, these data indicate that infants can map between the head movements and eyelid closures they see others perform and their own head movements and their own eye closures. The infant's experience is that eye closure cuts off the infant's own perceptual access. This experience may provide a basis for imbuing the eye-closures of others with felt experiential content.

This theorizing can also can help us make sense of the finding that young infants have more advanced understanding of eye-closure than blindfolds (Brooks & Meltzoff 2002). Certainly, 1-year-olds are well versed with voluntary looking away and eye closing to cut off unwanted stimuli. This bodily act is well mastered. Its meaning when used by others may therefore be in advance of the understanding of inanimate occluders. Our intervention experiment training infants with blindfolds gave them the experiential basis for appreciating the situation of another person who wore a blindfold.

Overturning the myth of the asocial newborn

A stumbling block for classical theories was that the self-other equivalence was postulated to be late developing – emerging from language or complex cognitive analyses. The last quarter century of research stands this proposition on its head. It indicates that young infants register the acts of others and their own acts in commensurate terms. *The recognition of self-other equivalences is the starting point for social cognition – a precondition for infant development, not the outcome of it.*

Given this facile self-other mapping, early social encounters are more interpretable to infants than supposed by Freud, Skinner, and Piaget. Infants have a storehouse of experience from which to draw: They can use the experienced subjectivity of self as a scaffold for the subjectivity of others. The child's intersubjectivity is thus not restricted to decoding minds in isolation or abstraction through 'cool cognition,' but involves felt immediacy through bodily actions as well.

The neural circuits underlying this preverbal human intersubjectivity are still being sought. Some of the most interesting advances in next decade may come from developmental social neuroscience. The task will be to consider intersubjectivity, imitation, mirror neurons, empathy, and much more, collaboratively from both a developmental and neuroscience perspective. Our joint purpose will be to crack one of the most urgent and ancient cries for human meaning: Am I alone? Do others feel what I'm feeling? This also is the baby's quest.

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Note

1. It is possible that displays can be constructed that fool infants, as they do adults. Can a computer be considered intentional? Or is it just an inert hunk of plastic and silicon? We do not know the necessary and sufficient conditions for infants ascribing purposiveness 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., researchers have used 2-D spots that leap and move spontaneously on a TV screen, Csibra 2003 and Gergely 2002). 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 (1995) gives a lower boundary (infants fail) and real people with whom the infant has an intersubjective relation give an upper boundary (infants succeed). There is a lot of room in between for more empirical research.

References

Argyle, M., & Cook, M. (1976). *Gaze and Mutual Gaze*. Cambridge, UK: Cambridge University Press.

Bakeman, R., & Adamson, L. B. (1984). "Coordinating attention to people and objects in mother-infant and peer-infant interaction." *Child Development,* 55, 1278–1289.

Baldwin, D. A. (1995). "Understanding the link between joint attention and language." In C. Moore & P. J. Dunham (Eds.), *Joint Attention: Its Origins and Role in Development* (pp. 131–158). Hillsdale, NJ: Erlbaum.

Baldwin, D. A., & Moses, L. J. (2001). "Links between social understanding and early word learning: Challenges to current accounts." *Social Development, 10,* 309–329.

Baldwin, J. M. (1906). *Mental Development in the Child and the Race: Methods and Processes* (3rd ed.). New York: Macmillan.

Bargh, J. A., & Chartrand, T. L. (1999). "The unbearable automaticity of being." *American Psychologist, 54,* 462–479.

Bates, E., Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The Emergence of Symbols: Cognition and Communication in Infancy*. New York: Academic Press.

Beebe, B., Rustin, J., Sorter, D., & Knoblauch, S. (2003). "An expanded view of intersubjectivity in infancy and its application to psychoanalysis." *Psychoanalytic Dialogues, 13,* 805–841.

Beebe, B., Sorter, D., Rustin, J., & Knoblauch, S. (2003). "A comparison of Meltzoff, Trevarthen, and Stern." *Psychoanalytic Dialogues, 13*, 777–804.

Bråten, S. (1998a). "Infant learning by altercentric participation: The reverse of egocentric observation in autism." In S. Bråten (Ed.), *Intersubjective Communication and Emotion in Early Ontogeny* (pp. 105–124). Cambridge: Cambridge University Press.

Bråten, S. (1998b). "Intersubjective communion and understanding: Development and perturbation." In S. Bråten (Ed.), *Intersubjective communication and emotion in early ontogeny* (pp. 372–382). Cambridge: Cambridge University Press.

Bråten, S. (2003). "Participant perception of others' acts: Virtual otherness in infants and adults." *Culture & Psychology, 9,* 261–276.

Bråten, S. (2004). "On the foundations of (pre)verbal intersubjectivity: Introduction to a symposium in the Norwegian Academy of Science and Letters." *Impuls, 3,* 91–95.

Brooks, R., & Meltzoff, A. N. (2002). "The importance of eyes: How infants interpret adult looking behavior." *Developmental Psychology, 38,* 958–966.

Brooks, R., & Meltzoff, A. N. (2005). "The development of gaze following and its relation to language." *Developmental Science, 8*, 535–543.

Bruner, J. (1983). *Child's Talk: Learning to Use Language*. New York: Norton.

Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., Seitz, R. J., Zilles, K., Rizzolatti, G., & Freund, H.-J. (2001). "Action observation activates premotor and parietal areas in a somatotopic manner: An fMRI study." *European Journal of Neuroscience, 13,* 400–404.

Butterworth, G. (2001). "Joint visual attention in infancy." In G. Bremner & A. Fogel (Eds.), *Blackwell Handbook of Infant Development* (pp. 213–240). Oxford: Blackwell.

Camaioni, L., Perucchini, P., Bellagamba, F., & Colonnesi, C. (2004). "The role of declarative pointing in developing a theory of mind." *Infancy, 5,* 291–308.

Carpenter, M., Nagell, K., & Tomasello, M. (1998). "Social cognition, joint attention, and communicative competence from 9 to 15 months of age." *Monographs of the Society for Research in Child Development, 63* (4), Serial No. 255.

Chartrand, T. L., & Bargh, J. A. (1999). "The chameleon effect: The perception-behavior link and social interaction." *Journal of Personality and Social Psychology, 76,* 893–910.

Csibra, G. (2003). "Teleological and referential understanding of action in infancy." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *358*, 447–458.

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

Decety, J. (2002). "Is there such a thing as functional equivalence between imagined, observed, and executed action?" In A. N. Meltzoff & W. Prinz (Eds.), *The Imitative Mind: Development, Evolution, and Brain Bases* (pp. 291–310). Cambridge: Cambridge University Press.

Decety, J., Chaminade, T., Grèzes, J., & Meltzoff, A. N. (2002). "A PET exploration of the neural mechanisms involved in reciprocal imitation." *NeuroImage*, *15*, 265–272.

Desimone, R. (1991). "Face-selective cells in the temporal cortex of monkeys." *Journal of Cognitive Neuroscience, 3,* 1–8.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., & Pethick, S. J. (1994). "Variability in early communicative development." *Monographs of the Society for Research in Child Development, 59* (5), Serial No. 242.

Franco, F., & Butterworth, G. (1996). "Pointing and social awareness: Declaring and requesting in the second year." *Journal of Child Language, 23,* 307–336.

Freud, S. (1911). "Formulations on the two principles of mental functioning." In J. Strachey (Ed.), *The Standard Edition of the Complete Psychological Works of Sigmund Freud* (Vol. 12) (pp. 215–226). London: Hogarth Press.

Frith, C. D., & Wolpert, D. M. (2003). "Introduction." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 358,* 431–434.

Gallagher, S. (2001). "The practice of mind: Theory, simulation or primary interaction?" *Journal of Consciousness Studies*, *8*, 83–108.

Gallagher, S. (2004). "Understanding interpersonal problems in autism: Interaction theory as an alternative to theory of mind." *Philosophy, Psychiatry, & Psychology, 11*, 199–217.

Gallagher, S., & Meltzoff, A. N. (1996). "The earliest sense of self and others: Merleau-Ponty and recent developmental studies." *Philosophical Psychology, 9,* 211–233.

Gallese, V. (2003). "The manifold nature of interpersonal relations: The quest for a common mechanism." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 358*, 517–528.

Gallese, V. (2005). "Being like me: Self-other identity, mirror neurons, and empathy." In S. Hurley & N. Chater (Eds.), *Perspectives on Imitation: From Neuroscience to Social Science* (Vol. 1: Mechanisms of imitation and imitation in animals) (pp. 101–118). Cambridge, MA: MIT Press.

Gergely, G. (2002). "The development of understanding self and agency." In U. Goswami (Ed.), *Handbook of Childhood Cognitive Development* (pp. 26–46). Oxford: Blackwell Publishers.

Goldman, A. I. (2005). "Imitation, mind reading, and simulation." In S. Hurley & N. Chater (Eds.), *Perspectives on Imitation: From Neuroscience to Social Science* (Vol. 2: Imitation, human development, and culture) (pp. 79–93). Cambridge, MA: MIT Press.

Gopnik, A. (1982). "Words and plans: Early language and the development of intelligent action." *Journal of Child Language, 9,* 303–318.

Gopnik, A. (1988). "Three types of early word: The emergence of social words, names and cognitive-relational words in the one-word stage and their relation to cognitive development." *First Language, 8,* 49–70.

Gopnik, A., & Meltzoff, A. N. (1986). "Relations between semantic and cognitive development in the one-word stage: The specificity hypothesis." *Child Development, 57,* 1040–1053.

Gopnik, A., & Meltzoff, A. N. (1997). *Words, thoughts, and theories*. Cambridge, MA: MIT Press.

Gopnik, A., Meltzoff, A. N., & Kuhl, P. K. (1999). *The Scientist in the Crib: Minds, Brains, and How Children Learn*. New York: Morrow.

Gordon, R. M. (2005). "Intentional agents like myself." In S. Hurley & N. Chater (Eds.), *Perspectives on Imitation: From Neuroscience to Social Science* (Vol. 2: Imitation, human development, and culture) (pp. 95–106). Cambridge, MA: MIT Press.

Gross, C. G. (1992). "Representation of visual stimuli in inferior temporal cortex." In V. Bruce, A. Cowey, A. W. Ellis, & D. I. Perrett (Eds.), *Processing the Facial Image* (pp. 3–10). New York: Oxford University Press.

Gross, C. G., & Sergent, J. (1992). "Face recognition." *Current Opinion in Neurobiology, 2,* 156–161.

Heimann, M. (1998). "Imitation in neonates, in older infants and in children with autism: Feedback to theory." In S. Bråten (Ed.), *Intersubjective Communication and Emotion in Early Ontogeny* (pp. 89–104). Cambridge: Cambridge University Press.

Heimann, M. (2002). "Notes on individual differences and the assumed elusiveness of neonatal imitation." In A. N. Meltzoff & W. Prinz (Eds.), *The Imitative Mind: Development, Evolution, and Brain Bases* (pp. 74–84). Cambridge: Cambridge University Press.

Heimann, M., Strid, K., Smith, L., Tjus, T., Ulvund, S., & Meltzoff, A. N. (2006). "Exploring the relation between memory, gestural communication, and the emergence of language in infancy: A longitudinal study." *Infant and Child Development, 15*, 233–249.

Hobson, R. P. (2002). *The Cradle of Thought: Exploring the Origins of Thinking*. London: Macmillan.

Hobson, R. P., & Lee, A. (1999). "Imitation and identification in autism." *Journal of Child Psychology and Psychiatry, 40,* 649–659.

Hobson, R. P., & Meyer, J. A. (2005). "Foundations for self and other: A study in autism." *Developmental Science, 8*, 481–491.

Hobson, R. P., Patrick, M. P. H., Crandell, L. E., García Pérez, R. M., & Lee, A. (2004). "Maternal sensitivity and infant triadic communication." *Journal of Child Psychology and Psychiatry, 45,* 470–480.

Hurley, S., & Chater, N. (Eds.). (2005). *Perspectives on Imitation: From Neuroscience to Social Science*. (Vol. 1 and 2). Cambridge, MA: MIT Press.

Husserl, E. (1950/1960). *Cartesian Meditations: An Introduction to Phenomenology* (D. Cairns, Trans.). The Hague: Martinus Nijhoff.

Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). "Cortical mechanisms of human imitation." *Science, 286,* 2526–2528.

Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. (2006). "Empathy examined through the neural mechanisms involved in imagining how I feel versus how you feel pain." *Neuropsychologia, 44*, 752–761.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2006). "Neural circuits involved in imitation and perspective-taking." *NeuroImage*, *31*, 429–439.

Jellema, T., Baker, C. I., Oram, M. W., & Perrett, D. I. (2002). "Cell populations in the banks of the superior temporal sulcus of the macaque and imitation." In A. N. Meltzoff & W. Prinz (Eds.), *The Imitative Mind: Development, Evolution, and Brain Bases* (pp. 267–290). Cambridge: Cambridge University Press.

Johnson, S. C. (2000). "The recognition of mentalistic agents in infancy." *Trends in Cognitive Sciences, 4,* 22–28.

Kleinke, C. L. (1986). "Gaze and eye contact: A research review." *Psychological Bulletin, 100,* 78–100.

Kugiumutzakis, G. (1998). "Neonatal imitation in the intersubjective companion space." In S. Bråten (Ed.), *Intersubjective Communication and Emotion in Early Ontogeny* (pp. 63–88). Cambridge: Cambridge University Press.

Langton, S. R. H., Watt, R. J., & Bruce, V. (2000). "Do the eyes have it? Cues to the direction of social attention." *Trends in Cognitive Sciences, 4,* 50–59.

Liszkowski, U., Carpenter, M., Henning, A., Striano, T., & Tomasello, M. (2004). "Twelve-month-olds point to share attention and interest." *Developmental Science, 7*, 297–307.

Mahler, M. S., Pine, F., & Bergman, A. (1975). *The Psychological Birth of the Human Infant*. New York: Basic Books.

Mead, G. H. (1934). *Mind, Self, and Society from the Standpoint of a Social Behaviorist*. Chicago: University of Chicago Press.

Meltzoff, A. N. (1988). "The human infant as *Homo imitans*." In T. R. Zentall & B. G. Galef (Eds.), *Social learning: Psychological and biological perspectives* (pp. 319–341). Hillsdale, NJ: Erlbaum.

Meltzoff, A. N. (1995). "Understanding the intentions of others: Re-enactment of intended acts by 18-month-old children." *Developmental Psychology, 31,* 838–850.

Meltzoff, A. N. (1996). "The human infant as imitative generalist: A 20-year progress report on infant imitation with implications for comparative psychology." In C. M. Heyes & B. G. Galef (Eds.), *Social Learning in Animals: The Roots of Culture* (pp. 347–370). New York: Academic Press.

Meltzoff, A. N. (2006). "The 'like me' framework for recognizing and becoming an intentional agent." *Acta Psychologica*, doi:10.1016/j.actpsy.2006.09.005.

Meltzoff, A. N. (2007). "'Like Me': A foundation for social cognition." *Developmental Science, 10,* 126–134.

Meltzoff, A. N., & Brooks, R. (2004). "Development changes in social cognition with an eye toward gaze following." Symposium conducted at the Biennial meeting of the International Conference on Infant Studies, Chicago, Illinois.

Meltzoff, A. N., & Brooks, R. (2006). "Eyes wide shut: The importance of eyes in infant gaze following and understanding other minds." In R. Flom, K. Lee, & D. Muir (Eds.), *Gaze Following: Its Development and Significance* (pp. 217–241). Mahwah, NJ: Erlbaum.

Meltzoff, A. N., & Decety, J. (2003). "What imitation tells us about social cognition: A rapprochement between developmental psychology and cognitive neuroscience." *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, 358* 491–500.

Meltzoff, A. N., & Moore, M. K. (1977). "Imitation of facial and manual gestures by human neonates." *Science, 198,* 75–78.

Meltzoff, A. N., & Moore, M. K. (1983). "Newborn infants imitate adult facial gestures." *Child Development, 54,* 702–709.

Meltzoff, A. N., & Moore, M. K. (1989). "Imitation in newborn infants: Exploring the range of gestures imitated and the underlying mechanisms." *Developmental Psychology, 25,* 954–962.

Meltzoff, A. N., & Moore, M. K. (1994). "Imitation, memory, and the representation of persons." *Infant Behavior & Development, 17,* 83–99.

Meltzoff, A. N., & Moore, M. K. (1997). "Explaining facial imitation: A theoretical model." *Early Development and Parenting, 6,* 179–192.

Meltzoff, A. N., & Prinz, W. (Eds.). (2002). *The Imitative Mind: Development, Evolution and Brain Bases*. Cambridge: Cambridge University Press.

Merleau-Ponty, M. (1945/1962). *Phenomenology of Perception* (C. Smith, Trans.). London: Routledge & Kegan Paul.

Meyer, J. A., & Hobson, R. P. (2005). "Orientation in relation to self and other: The case of autism." *Interaction Studies, 5*, 221–244.

Moore, C., & Dunham, P. J. (Eds.). (1995). *Joint Attention: Its Origins and Role in Development*. Hillsdale, NJ: Erlbaum.

Moore, M. K., & Meltzoff, A. N. (2004). "Object permanence after a 24-hr delay and leaving the locale of disappearance: The role of memory, space, and identity." *Developmental Psychology, 40,* 606–620.

Morales, M., Mundy, P., & Rojas, J. (1998). "Following the direction of gaze and language development in 6-month-olds." *Infant Behavior & Development, 21*, 373–377.

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). "Responding to joint attention across the 6- through 24-month age period and early language acquisition." *Journal of Applied Developmental Psychology, 21,* 283–298.

Moses, L. J., Baldwin, D. A., Rosicky, J. G., & Tidball, G. (2001). "Evidence for referential understanding in the emotions domain at twelve and eighteen months." *Child Development, 72,* 718–735.

Mundy, P., Fox, N., & Card, J. (2003). "EEG coherence, joint attention and language development in the second year." *Developmental Science, 6,* 48–54.

Nehaniv, C. L., & Dautenhahn, K. (Eds.). (2007). *Imitation and Social Learning in Robots, Humans, and Animals: Behavioural, Social and Communicative Dimensions*. Cambridge: Cambridge University Press.

Perrett, D. I., Hietanen, J. K., Oram, M. W., & Benson, P. J. (1992). "Organization and functions of cells responsive to faces in the temporal cortex." In V. Bruce, A. Cowey, A. W. Ellis, & D. I. Perrett (Eds.), *Processing the Facial Image* (pp. 23–30). New York: Oxford University Press.

Piaget, J. (1952). *The Origins of Intelligence in Children* (M. Cook, Trans.). New York: International Universities Press.

Piaget, J. (1954). *The Construction of Reality in the Child* (M. Cook, Trans.). New York: Basic Books.

Piaget, J. (1962). *Play, Dreams and Imitation in Childhood* (C. Attegno & F. M. Hodgson, Trans.). New York: Norton.

Povinelli, D. J. (2000). *Folk Physics for Apes: The Chimpanzee's Theory of How the World Works*. New York: Oxford University Press.

Prinz, W. (2002). "Experimental approaches to imitation." In A. N. Meltzoff & W. Prinz (Eds.), *The Imitative Mind: Development, Evolution, and Brain Bases* (pp. 143–162). Cambridge: Cambridge University Press.

Prinz, W. (2005). "Construing selves from others." In S. Hurley & N. Chater (Eds.), *Perspectives on Imitation: From Neuroscience to Social Science* (Vol. 2: Imitation, human development, and culture) (pp. 180–182). Cambridge, MA: MIT Press.

Repacholi, B. M. (1998). "Infants' use of attentional cues to identify the referent of another person's emotional expression." *Developmental Psychology*, *34*, 1017–1025.

Repacholi, B. M., & Meltzoff, A. N. (In press). "Emotional eavesdropping: Infants selectively respond to indirect emotional signals." *Child Development*.

Rizzolatti, G. (2005). "The mirror neuron system and imitation." In S. Hurley & N. Chater (Eds.), *Perspectives on Imitation: From Neuroscience to Social Science* (Vol. 1: Mechanisms of imitation and imitation in animals) (pp. 55–76). Cambridge, MA: MIT Press.

Rizzolatti, G., Fadiga, L., Fogassi, L., & Gallese, V. (2002). "From mirror neurons to imitation: Facts, and speculations." In A. N. Meltzoff & W. Prinz (Eds.), *The Imitative Mind: Development, Evolution, and Brain Bases* (pp. 247–266). Cambridge: Cambridge University Press.

Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). "Premotor cortex and the recognition of motor actions." *Cognitive Brain Research, 3,* 131–141.

Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). "Neurophysiological mechanisms underlying the understanding and imitation of action." *Nature Reviews Neuroscience, 2,* 661–670.

Rochat, P., & Striano, T. (1999). "Social-cognitive development in the first year." In P. Rochat (Ed.), *Early Social Cognition: Understanding Others in the First Months of Life* (pp. 3–34). Mahwah, NJ: Erlbaum.

Rogers, S. J. (1999). "An examination of the imitation deficit in autism." In J. Nadel & G. Butterworth (Eds.), *Imitation in Infancy* (pp. 254–283). Cambridge: Cambridge University Press.

Rommetveit, R. (1998). "Intersubjective attunement and linguistically mediated meaning in discourse." In S. Bråten (Ed.), *Intersubjective Communication and Emotion in Early Ontogeny* (pp. 354–371). Cambridge: Cambridge University Press.

Skinner, B. F. (1953). *Science and Human Behavior*. New York: The Macmillan Company.

Skinner, B. F. (1983). *A Matter of Consequences*. New York: Alfred A. Knopf.

Smith, A. (1759/1976). *The Theory of Moral Sentiments*. Reprints of Economic Classics. New York: Oxford University Press.

Stern, D. N. (1985). *The Interpersonal World of the Infant: A View from Psychoanalysis and Developmental Psychology*. New York: Basic Books.

Tomasello, M. (1999). *The Cultural Origins of Human Cognition*. Cambridge, MA: Harvard University Press.

Tomasello, M. (2003). *Constructing a Language: A Usage-based Theory of Language Acquisition*. Cambridge, MA: Harvard University Press.

Tomasello, M., & Call, J. (1997). *Primate cognition*. New York: Oxford University Press.

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). "Understanding and sharing intentions: The origins of cultural cognition." *Behavioral and Brain Sciences, 28*, 675–691.

Toth, K., Munson, J., Meltzoff, A. N., & Dawson, G. (2006). "Early predictors of communication development in young children with autism spectrum disorder: Joint attention, imitation, and toy play." *Journal of Autism and Developmental Disorders*, doi:10.1007/s10803-006.0137-7.

Trevarthen, C. (1979). "Communication and cooperation in early infancy: A description of primary intersubjectivity." In M. Bullowa (Ed.), *Before Speech: The Beginning of Interpersonal Communication* (pp. 321–347). New York: Cambridge University Press.

Trevarthen, C., & Hubley, P. (1978). "Secondary intersubjectivity: Confidence, confiding and acts of meaning in the first year." In A. Lock (Ed.), *Action, Gesture, and Symbol: The Emergence of Language* (pp. 183–229). London: Academic Press.

Whiten, A. (2002). "The imitator's representation of the imitated: Ape and child." In A. N. Meltzoff & W. Prinz (Eds.), *The Imitative Mind: Development, Evolution, and Brain Bases* (pp. 98–121). Cambridge: Cambridge University Press.

Whiten, A., & Brown, J. D. (1998). "Imitation and the reading of other minds: Perspectives from the study of autism, normal children and non-human primates." In S. Bråten (Ed.), *Intersubjective Communication and Emotion in Early Ontogeny* (pp. 260–280). Cambridge: Cambridge University Press.

Williamson, R. A., & Markman, E. M. (2006). "Precision of imitation as a function of preschoolers' understanding of the goal of the demonstration." *Developmental Psychology, 42*, 723–731.

Wittgenstein, L. (1953). *Philosophical Investigations* (G. E. M. Anscombe, Trans.). Oxford: Blackwell.