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CHAPTER 5

Imitation and the Development of Language

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Before using words, children acquire a repertoire of conventional sounds and gestures to express intentions and to communicate. Some of these sounds and gestures develop from the ritualization of functional actions such as reaching, while others involve the imitation of actions that have conventional or agreed-on meanings, such as waving bye-bye, nodding, or pointing. At least three aspects of imitation are relevant to appreciating its role in the development of spoken language (Nadel & Butterworth, 1999). First, imitation is a form of social learning that involves observing others, listening to others, and learning from others. Second, imitation involves the acquisition of novel responses on the basis of social experience and reinforcement. Third, imitation can provide evidence that a child is able to form internal representations of the actions they observe and reproduce these representations in their own actions. Each of these aspects develops within the to-and-fro flow of social communication and the development of shared meanings (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979). These observations also apply to the development of spoken language. That is, children learn the meaning of words by observing how other people use them (for the purposes of communication). They then reproduce, or imitate, words they have learned the meaning of for the same purpose—to communicate. Imitation and language appear to be connected at the core level of developing understanding. For children with autism, the development of both imitation and spoken language is typically delayed and also deviates from the pattern seen in typical development.

At first glance the role of imitation in the ontogeny of the social and communicative impairments that characterize individuals with autism presents something of a conundrum. On one hand the phenomenon of echolalia, whereby some children with autism repeat back to the speaker a word or

phrase, seems to suggest an intact capacity in the child's ability to imitate, at least for language. On the other hand, many parents of preschoolers with autism report that their children do not copy everyday household activities such as vacuuming and using a hammer and nail that appear to come so naturally to typically developing toddlers. Indeed, deficits in imitation form part of the characteristic behavioral profile of preschoolers with autism (Charman & Baird, 2002; Rogers, 2001). To understand this apparent contradiction one needs to understand the role of imitation in social, communication, and language development and in particular the psychological mechanisms that underlie the capacity for imitation. Imitation has long been a topic of interest in developmental psychology. More recently, it has been a focus of empirical activity and theoretical interest in several fields of scientific endeavor, including developmental psychopathology, cognitive neuroscience, comparative psychology, and ethology. The purpose of this chapter is to explore this common ground between action–imitation and language development. I ask what developmental processes are common to action–imitation and the development of verbal skills. In what ways is imitation necessary for language development and on what processes are imitation and language both commonly dependent?

I review both historical and more recent work from a number of these fields with a focus on the role of imitation in the development of language and communication. I also highlight aspects of the atypical development of imitation in children with autism that reflect broader (i.e., non-language-specific) impairments in social communication that define the disorder.

THE PIAGETIAN VIEW: LET'S START AT THE BEGINNING

The first comprehensive and authoritative developmental theory giving imitation a central role in the development and onset of language was Piaget's (1945/1962; Piaget & Inhelder, 1966/1969). Piaget described how body, facial, and vocal imitation developed throughout the six stages of sensorimotor development. No true imitation was possible in stage I (0–1 months) and any pseudo-imitative responses were considered reflexes. Sporadic imitation of "circular reactions" occurred during stage II (1–5 months) when an adult modeled behaviors that had just been displayed by the baby. During stage III (6–9 months), simple sounds and manual gestures that were already within the repertoire of the infant could be imitated. Critically, Piaget argued that these could be accomplished on the basis of an *intra*modal (within-modality) matching process. During stages IV and V (9–18 months), two critical aspects of early imitation begin to emerge. First, infants begin to imitate facial gestures that require *inter*modal (cross-modality) matching that is beyond the cognitive abilities of younger infants. Second, although not fully established before stage VI (18–24 months), the infant becomes capable of deferred imitation. Both of these landmark achievements require increasing

representational capacity on the part of the infant whereby he or she is able to form, manipulate, store, and retrieve cognitive representations or symbols. Piaget linked this to the concurrent development of symbolic play and spoken language, both of which he also argued require such representational skills.

While other theorists, notably Werner and Kaplan (1963) and Vygotsky (1934/1986), argued for a greater role for social interaction between children and adults in the development of such symbolic skills, Piaget's theory was the dominant one within developmental psychology at the time. For Piaget, representation begins when there is simultaneous differentiation and coordination between signifiers (the internal representation) and the signified (the content of the action). Imitation involves the first demonstration of such a differentiation between the observable action and the mental image or internalization of it. Under Piaget's account, such representational abilities underlie deferred imitation (the later reproduction of an earlier-observed action), the object concept, symbolic play, and spoken words.

Subsequent to Piaget's account, several strands of research emerged that all addressed the same question: What is the association between aspects of nonverbal communication and representational development in infancy and (later) language development? Each strand adopted a slightly different focus both in terms of the form of nonverbal communicative behavior that was studied and in terms of the extent to which the social and communicative context was emphasized. The Piagetian tradition outlined previously concentrated on symbolic (pretend) play and deemphasized the social and communicative context. Another tradition emphasized the role of joint attention, that is, how children learn to attend to objects and events that adults attend to, in language development (Bates et al., 1979; Bates, Thal, Whitesell, Fenson, & Oakes, 1989; Bruner, 1975a, 1975b; Tomasello, 1988; Tomasello & Farrar, 1996; Tomasello & Todd, 1983). A second psycholinguistic tradition (see below) also placed the social–communicative infant–caregiver dyad firmly in the center of things but focused on the link between immediate and deferred imitation of gestural communication and the emergence of language (Bates et al., 1979, 1989).

LANGUAGE DEVELOPMENT: PRAGMATICS VIEW

There is empirical evidence that reveals a remarkable coincidence in timing between the development of imitation skills and language onset in the first 2 years of life (for reviews, see Bates & Dick, 2002; Fenson et al., 1994). It appears that nonverbal gestures develop hand-in-hand with verbal communication skills and thus that the temporal coincidence is close. For example, babbling usually onsets between the age of 6–8 months and has been linked to the onset of rhythmic hand clapping and banging (Locke, 1993). Between 6 and 10 months of age typically developing children begin to understand spoken words and at the same time deictic (e.g., showing and pointing) and conventional gestures (e.g., waving bye-bye) begin to emerge (Bates et al., 1979).

The coincidence of emergence between gestural communication and language continues, at least for a period, after spoken language emerges. For example, the modal age for first spoken words is around the child's first birthday and about the same time children begin to produce functional or appropriate actions on objects (e.g., drinking from a toy cup) in their play, often initially in imitation of adult models of such acts and then increasingly spontaneously and generatively (Bates et al., 1989; Fenson et al., 1994). Typically, word combinations begin to appear between the middle of a child's second year of life and his or her second birthday, and around the same time gestures and words are also used in combination (Capirci, Iverson, Pizzuto, & Volterra, 1996). Naturally, the developmental tenet that temporal coincidence does not in any way imply a causal link between two phenomena applies. Nonetheless, what captured Piaget's interest was how to explain the apparent association between the two phenomena—gestures on the one hand, language on the other—that share common functions (communication and social interaction) but take very different forms. As we shall see later on, verbal imitation also plays a role in the development of language. However, in the nonverbal modality of social interaction and communication, imitation of gestures helps "bridge" the divide between receptive reference of symbols (word comprehension) and active reference of symbols (word production) (Volterra & Erting, 1990).

Whereas several aspects of Piaget's theory and timeline have been overtaken by subsequent work (see below), his writings and those of his contemporaries within the developmental psychology field laid the groundwork in terms of delineating the critical competencies that are required by most infants throughout the relatively short period of infancy. They also provided a nomenclature to describe the cognitive processes that underlie imitation. Two critical advances, now both considered landmarks, changed the majority view within the developmental field. The first was a series of empirical studies conducted by Meltzoff and his colleagues and the second was an establishment of *psycholinguistic* theory firmly within a social context, most notably in the writings of Bruner and Bates. The next two sections of the chapter will outline each of these advances, in turn.

MELTZOFF'S CHALLENGE TO PIAGET: LET'S START AT THE BEGINNING (AGAIN)

Meltzoff and Moore's (1977, 1983) seminal finding that neonatal infants could imitate certain facial gestures launched a series of studies whose outcomes both overturned the timetable and challenged the content of Piaget's account of infant cognitive development. According to Meltzoff and Moore (1977) this suggested that the effect was not simply an arousal reaction but evidence that neonates were making specific (*inter*modal) mappings between the modeled facial gestures of the experimenter and their own executed motor responses. They developed a theoretical model of infant facial imitation that

involves what they called active intermodal mapping (AIM). The critical process involves matching to target, whereby the infant's self-produced movements provide proprioceptive feedback that can be compared with the visually specified target. Some innate propensity to social motivation—as evidenced by the innate preference for faces or biological motion (de Haan & Nelson, 1999)—presumably underlies the recruitment of this cognitive system when neonates are faced with an adult. Meltzoff further extended his model to include oral, visual, and speech perception production mapping in infants in the first few months of life (Kuhl & Meltzoff, 1996; Meltzoff & Borton, 1979; see Meltzoff, 1999, 2002, for reviews). This timetable of representational development was revolutionary compared to that set out by Piaget, whereby the infant is not capable of such complex representational thought until around 18–24 months of age.

Meltzoff then initiated a series of experiments with older infants that investigated their imitation of modeled actions on objects in order to test whether a similar adjustment to Piaget's timetable for deferred imitation was required (see Meltzoff, 2002). Using an "observation only" design, Meltzoff (1988a, 1988b) demonstrated that 9-month-old infants were able to reproduce actions on objects they have observed following a 24-hour delay, compared to 18 months of age under Piaget's sensorimotor timetable. Other studies have demonstrated some facility for deferred imitation in infants as young as 6 months of age (Barr, Dowden, & Hayne, 1996). Perhaps the most remarkable description is of 14-month-old children reproducing the modeled action of leaning forward and touching a box with their forehead in order to illuminate it (Meltzoff, 1988b). This action was not produced by any children in the control group who had not seen the demonstration of the (deliberately) unusual method of lighting the box. Notably this particular response was also produced by very few children with autism in one of our own studies (Charman et al., 1997).

What is striking when conducting this experiment with typically developing infants is how often reproduction of this unnecessary and certainly somewhat unusual action is accompanied by cries of laughter from the infants and lots of eye contact with the adult. As we shall see later, in the real-world imitation is fun and sociable and reveals to us the thought processes and social motivations of the infant. It is also noticeable in the "light box" paradigm that sometimes children push the top of the box with their hand in order to illuminate the box and only then, as their second action, do they reproduce the modeled forehead "bow." Other infants reproduce the bow first and then go on to use their hand to illuminate the box on the second attempt. Imitation is a context and an activity through which infants learn about both people and things.

Further decoupling of memory and representation of actions occurs as infants become able to transfer across contexts and generalize to objects of different color and size (see Meltzoff, 2002, for a review). More direct evidence also emerged that these developing cognitive abilities were associated

with infants' emerging language abilities. In a series of studies, Gopnik and Meltzoff (1986, 1987) demonstrated that during the second year of life different aspects of object representation can show considerable decalage and, furthermore, that specific aspects of object concept are related to specific language accomplishments. Thus, the onset of object permanence skills and the onset of infants' use of disappearance words are more closely yoked in time than object permanence and success/failure words (Gopnik & Meltzoff, 1986). Conversely, the onset of the ability to solve means–ends tasks is specifically yoked to the infants' use of success/failure words. A second study provided evidence that the naming explosion was linked to infants' ability to categorize objects (Gopnik & Meltzoff, 1987). These studies indicated that different aspects of infants' emerging understanding of objects were more closely linked to specific aspects of language than to each other. Under Meltzoff's thesis, a *supra*modal ("higher-level," modality unconstrained) matching system underlies the imitation of gestures, sounds, and actions on objects, and imitation itself is necessary for language learning.

THE PSYCHOLINGUISTIC APPROACH TO INFANT LANGUAGE AND COGNITION

While Meltzoff's search started and then developed from his attempts to understand neonatal imitation and ended up as an account of how infants learn language (and indeed to read intentions and then to mentalize; see Meltzoff, 2002), at the same time a somewhat different theory was under development that attempted to explain the problem first articulated by Wittgenstein (1953): How can a child learn a word when no nonlinguistic procedures can unambiguously illustrate its reference? Bruner (1975a, 1975b) outlined a psycholinguistic approach that established continuities between prespeech communication and language. Similar to Meltzoff's conclusions, Bruner (1975a) said: "To master language a child must acquire a complex set of broadly transferable or generative skills—perception, motor, conceptual, social, *and* linguistic—which when appropriately coordinated yield linguistic performances" (p. 256, emphasis in original). Such processes help the infant acquire language because they are used by the infant in communicative exchanges with her caregiver as the infant enters into social exchanges and intentionally laced communication about the objects and about the social world:

> For if the child, say, already knows (as we shall see) many of the conventions for give-and-take exchanges and how to conduct them by appropriate, nonlinguistic signalling, he is equipped better to interpret or "crack the code" of linguistic utterances used as regulators of such exchanges. (Bruner, 1975a, p. 261)

Critical to this process, "conversations" during the first year of life between the infant and his or her caregiver involve both partners using gesture, pos-

ture, and nonword vocalizations for the purposes of bringing the other partner's attention to an object or action or state. A second critical aspect is deixis—the *function* of pointing or *specifying from the perspective of a participant* in an act of speech or writing. This requires the infant use of spatial, temporal, and interpersonal contextual features of situations to guide joint attention or joint action. It is only through a history of multiple interpersonal exchanges that the infant is ready and able to understand that the words that accompany such nonlinguistic interchanges "stand for" events, actions, and objects. That is, conventional symbols can only be learned when the infant has already established a rich nonlinguistic "vocabulary" for communicative interchange.

Empirical evidence to support Bruner's thesis was soon available. Bates and colleagues demonstrated that linguistic and nonlinguistic social cognitive skills, including communicative gestures, words, and the imitation of actions, were highly related to each other at the end of the first year of life, and further that infants' imitation ability predicted the later nonlinguistic gestural competence and their spoken language ability (Bates et al., 1979, 1989). Bates and colleagues (1979) produced some of the first empirical evidence that demonstrated longitudinal associations between joint attention abilities, including protodeclarative pointing and following eye gaze, and later language ability (followed later by Carpenter, Nagell, & Tomasello, 1998; Mundy & Gomes, 1998; Tomasello & Farrar, 1986). Bates and colleagues (1989) found that in typically developing infants "imitating gestures with objects" (functional play acts) at 13 months of age was associated with expressive language ability 9 months later.

JOINT ATTENTION

Over the next two decades a significant body of evidence emerged that the child's exposure to activities involving joint attention and joint engagement, and the degree to which adult language is sensitive to the child's focus of attention in the language learning situation, are important for word learning and for promoting general linguistic competence (e.g., Tomasello & Farrar, 1986; Tomasello & Todd, 1983). This pattern of findings was confirmed in a recent longitudinal study that followed 24 infants at monthly intervals from 9 to 15 months of age (Carpenter, Nagell, & Tomasello, 1998). Carpenter, Nagell, and Tomasello (1998) measured a wide range of social cognitive skills, including imitation of arbitrary actions and imitation of instrumental actions. The former but not the latter were related to the age of emergence of referential language (see also Meltzoff, 1995). Similarly, imitative learning was associated with the infant following an adult's point toward an object. Carpenter, Nagell, and Tomasello concluded that in order to learn referential words, infants must be able to imitate sounds that are only arbitrarily connected to their reference and, furthermore, that both the imitation of arbitrary actions

and point following involve the infants in following the adult's intention. Carpenter, Nagell, and Tomasello's longitudinal study provided evidence that in typically developing infants, imitation, joint attention, joint engagement, and understanding other's intentions are all associated with later language ability

MEANS–GOALS AND INTENTIONALITY

Another aspect of the psycholinguistic approach is the recognition that what is represented in an imitative context goes beyond the symbolic or cognitive level and involves some representation of the internal states of the child's imitative partner. Carpenter and Call (2002) elucidated a theoretical framework for understanding the different sources of information that may influence an observer's response to any modeled act (see Whiten, Horner, Litchfield, & Marshall-Pescini, 2004, for an alternative framework). A modeled action produces at least three products: *goals* (the demonstrator's aim or intention), *actions* (motor patterns), and *results* (the transformed environment). Depending on the context, the object, the infant's motivation and understanding, the familiarity of the adult partner, and social cues the adult gives out, infants' attention can be differentially drawn to different aspects of the social learning situation. Meltzoff developed the "behavioral reenactment paradigm" to test whether the infant follows a model's actions or goals (intentions). Meltzoff (1995) found that at 18 months, infants copied the intended but unconsummated action (though see Huang, Heyes, & Charman, 2002, for an alternative, more conservative interpretation). Using the same paradigm, Bellagamba and Tomasello (1998) found that 18-month-old, but not 12-month-old, infants did likewise. Several other ingenious paradigms have been developed to test which of these sources of information infants respond to. Carpenter, Akhtar, and Tomasello (1999) showed that 18-month-olds copy intended but not "accidental" actions on objects and Bekkering, Wohlschläger, and Gattis (2000) showed that school-age children imitate motor patterns of a model dependent on what they perceive to be the model's goal. Recently, Tomasello, Carpenter, Call, Behne, and Moll (2005) have also highlighted the role of social motivation in drawing infants toward intentional understanding rather than the actions or the outcome. In essence, fully understanding the impairments in the development of imitation and spoken language in autism may also require us to understand the social impairment that lies at the core of autism (see Charman, 2005; Hobson, 1993; Hobson & Meyer, Chapter 9, this volume; Williams, 2005).

Infants might copy an action or a result but be oblivious to the demonstrator's goal. Although two studies have shown that children with autism do produce the intended but unconsummated act in Meltzoff's behavioral reenactment paradigm (Aldridge, Stone, Sweeney, & Bower, 2000; Carpenter, Pennington, & Rogers, 2001), it is possible that they are producing these responses using "lower level" nonintentional means such as stimulus enhance-

ment and object affordance (Charman & Huang, 2002; Heyes, 2001; Williams, Whiten, & Singh, 2004). It may be that for children with autism, mapping the relation between the action, the goal, and the model's intention is more difficult and that, depending on the circumstances, merely being able to reproduce the action, the goal (or even the intention) is insufficient to be a proficient imitator in everyday life.

While in typical development learning about objects via imitation and communicating with people are closely tied together, albeit at a much earlier stage than Piaget originally envisaged, one should not assume that the same is necessarily true for children with autism. A good demonstration of this principle is the finding by Hobson and Lee (1999; see Hobson & Meyer, Chapter 9, this volume) that teenage children with autism reproduced the target action of arbitrary actions on objects (the goal) but not the "style" of the action. Interestingly, few of the participants with autism adopted the orientation to self that had been modeled with the objects. While by this stage in later childhood children with autism can reproduce simple actions (see also Charman & Baron-Cohen, 1994), they do not step inside the model's mind and body as much as other children, what Hobson has referred to as a "lack of identification." In understanding the profile of intact and impaired imitative responses that have been shown in various imitation paradigms employed with children with autism (see Williams et al., 2004, for a review), it is important to recognize that imitation is not all-or-none but more or less. A variety of social and nonsocial learning processes affect how children respond to what they observe and what motivates and drives their response.

Imitation plays a role, as do other preverbal social cognitive skills (in particular joint attention and joint action), in the "meld" of nonverbal communicative interaction that infants experience during the first and second year of life. By the time infants begin to talk they are well versed as communicators and social partners. At a cognitive level, infants require the capacity to represent symbolic referents in memory and use these in interchanges, at first in combination with the nonverbal precursors and then increasingly in isolation. However, another strand of theoretical and empirical work exists that would consider that this position overemphasizes the role of representational or symbolic thought. It places the development of these precursor social communicative abilities more centrally in the social *I–Thou* interchange, and it is to this literature I turn next.

THE DYADIC INTERCHANGE

A rich line of empirical studies that have adopted detailed analysis of infant–adult (usually caregiver) interactions has demonstrated that as well as copying adults, infants are sensitive to and engage in back-and-forth "protoconversations" from as young as 2 months of age (Bateson, 1975; Trevarthen, 1974). Theorists have taken the demonstration of neonatal imitation as evi-

dence that newborns are "hardwired" to perceive, respond to, and relate directly to other persons (labeled "primary intersubjectivity") (Trevarthen, 1979). Throughout the first year of life, as described previously, infants gain an understanding of meaning via engaging in cooperative activities with caregivers in joint activity with objects and events in the world. This has been described by Trevarthen (1979) as "secondary intersubjectivity," which involves the infant actively coordinating his or her interests in objects with the attention and apparent intentions of the partner. One important characteristic of this coordination is the timing element that leads to a back-and-forth reciprocity between carer and infant.

Trevarthen, Kokkinaki, and Fiamenghi (1999) summarize several experimental studies that are examples of protoconversations that involve rhythmic attunement of mother and infant vocalizations in the first few months of life (e.g., Papousek, 1989), with the mother protracting, amplifying, and enhancing versions of the infant's sounds. Such exchanges are accompanied by other sympathetic reactions that are nonimitative such as smiles, mutual gaze, hand gestures, and affective vocal expressions. Stern has called these supportive emotional colored attunements (Stern, 1985). By 6 months of age, more extended and complex vocal and emotional interchanges are possible with teasing games, baby songs (nursery rhymes), and action games where the affect, the vocalizations, and the movements of the mother and child take on a shared rhythmic pattern (see Trevarthen et al., 1999, Figure 5.4). The infant will either alternate with the mother or coincide on emotional climaxes of excitement (Stern, 1975). Out of such exchanges grow imitation of gestures and sounds and the use of these and other prelinguistic devices to refer to objects and emotions (social referencing) during the second half of the first year of life (e.g., Bates et al., 1979; Carpenter, Nagell, & Tomasello, 1998, summarized earlier).

In addition to imitating there is the other side of being imitated. There are other sources of evidence that infants are aware of being imitated. Field (1977) found that 7-month-old infants looked more toward their mother when she imitated than when she interacted in another way. Nadel (2000, cited in Nadel, Guérini, Pezé, & Rivet, 1999) found evidence that infants as young as 2 months of age were aware of being imitated. As well as increased looking, Nadel found that infants smiled and vocalized more when the mother's behavior was contingent or imitative of the child's. Interestingly, there was considerable variability in how consistently these actions and reactions were shown both by parents and by children. Nadel also reported that at least one 2-month-old produced a sequence of imitate–imitated–imitate or "imitation in return," similar to the vocalization exchanges summarized by Trevarthen and colleagues (1999). Three-month-olds are already able to detect contingency between their own bodily movements and those display on a television screen (Rochat & Morgan, 1995). However, while 3-month-olds preferred contingency, 5-month-olds preferred noncontingency, as if fascinated by the unexpected view of their own movements (see Gergely & Wat-

son, 1999, for a pilot study of contingency in young children with autism, which deserves further investigation).

The role of social interaction in imitation continues into the preschool years and includes the effects of being imitated by peers as well as adults (Eckerman, Davis, & Didow, 1989). Being imitated provokes a social response in typically developing children. For example, Eckerman and Stein (1990) showed that when 2-year-olds' actions on objects were imitated by an adult they not only continued to play with the object for longer but engaged in social imitative games and looked more to the adult who imitated them. Shared engagement in objects (toys) in joint play between infants and their mothers ("symbol-fused engagement") is also associated to individual differences in language onset and language facility at age 2½ (Adamson, Bakeman, & Deckner, 2004). Similar evidence is available for the effects of verbal imitation in sustaining verbal interaction (Bloom, Rocissano, & Hood, 1976; Snow, 1983). (See Masur, Chapter 2, this volume, for a review of imitation during the toddler period.)

These studies focus on the social *exchange* and the development of turn taking, rather than the somewhat more "unidirectional" approaches where adults elicit responses from children in the more experimental studies and are important reminders that during infancy infants are deeply involved in communicative exchanges with caregivers. It is through such exchanges that infants develop an increasing repertoire of prelinguistic communicative forms, including gestures, imitation, nonword vocalizations, and affective expressions, which are the building blocks from which spoken language develops in typical development. As Nadel summarizes:

> Turn-taking, topic-sharing, understanding the other's intentions, negotiating shared goals through codes and routines, all these features of verbal language are prepared by the use of the imitative system. The imitative language can therefore be seen as a semantic foundation for verbal language, in the same way in which Donald (1991) describes the mimetic stage of humankind, compared to the stage of spoken language. (2002, p. 58)

INTEGRATION BETWEEN COMPONENTS

It appears that the development of the system that is involved in recognition of self–other correspondence is an integrated supramodal system so that at the behavioral level, similar developments are seen to occur in the vocal, motor, facial, and affective modalities. In real life these modalities are not as separate as they are described in psychology textbooks but together rather they are all used in social communication. One important question for understanding imitation and language development in autism is whether the fundamental impairments in social communication development lies at the level of these individual components (or modalities) or rather from deficits in the supra-

modal integration required for the components to function together. A recent brain-based model of deficits in interconnectivity between different systems that are recruited for complex problem solving (which would include social situations) might lead researchers interested in early social communication impairments in autism to design studies to answer this question (Just, Cherkassky, Keller, & Minshew, 2004).

There is some evidence that imitation of actions on objects and affective responsivity are also associated in autism. Charman and colleagues (1997) found impairments in both action imitation and an impoverished response to a display of feigned distress in toddlers with autism and Dawson, Meltzoff, Osterling, Rinaldi, and Brown (1998; statistical association cited in Gopnik, Capps, & Meltzoff, 2000) found that performance on tests of imitation and affective responsivity was associated in preschoolers with autism. To a large extent, investigations of imitation abilities and emotional responsivity have been conducted separately to date in the autism field. Emphasizing the value of studying imitation in a more naturalistic social context, Nadel and colleagues (1999) found that within a sample of school-age children with autism, the amount of imitative behavior was strongly associated with the amount of nonimitative social behavior. The development of experimental paradigms that include vocal, motor, facial, and affective modalities might lead to a clearer understanding of how "imitation" might fractionate (if at all) in autistic development.

In another study that examined relationships between these processes within a sample of children with autism, Rogers, Hepburn, Stackhouse, and Wehner (2004) found that object and oral imitation were associated with symptom severity and initiation of joint attention skills, unlike imitation of manual (nonconventional) gestures, which was associated with expressive language ability. This latter finding is consistent with an earlier study by Stone, Ousley, and Littleford (1997) who demonstrated some specificity of longitudinal associations from 2 to 4 years of age between imitation of body movements but not actions on objects with later expressive language skills. Perhaps as suggested previously, the social-communication system is more fractionated in autism, though whether this is due to impairments in separable components of the system or impairments in integrative processing remains to be determined.

LINGUISTIC PROCESSING: A WORD ABOUT SPEECH

Imitation of actions and gestures alone is not sufficient for (spoken) language acquisition and learning the acoustics of speech and an infant's exposure to socially modulating vocal partners and verbal imitation play an important role too (Kuhl, 2000). For example, contingent vocalizations by mothers promote speech production (Goldstein, King, & West, 2003), and speech discrimination at 6 months of age predicts language competence at 2 years of age

(Tsao, Liu, & Kuhl, 2004). The debate between Skinner's (1957) operant view of language learning encapsulated in his book *Verbal Behavior* and Chomsky's (1957) nativist, modularist position has been overtaken by empirical evidence that infants undertake a perceptual learning process during which they detect patterns in speech input, exploit statistical properties of speech input, and are perceptually altered by exposure to speech (see Kuhl, 2000, for a review). Vocal imitation links speech perception and production from early in the first year of life and auditory, visual, and motor information are all employed in speech comprehension and production. However, perception is not sufficient and a social interest in speech is also fundamental to language learning (Liu, Kuhl, & Tsao, 2003).

What do we know about linguistic and social processing of speech in children with autism? We know that social orienting to speech is impaired in young children with autism (Dawson et al., 1998, 2004). There is also some tentative evidence that children with autism show a selective impairment in the attention they pay to speech sounds (Ceponiene et al., 2003; Gervais et al., 2004) and consequent lessened activation of brain regions that process speech such as the superior temporal sulcus (STS). Notably, the STS is also involved in the detection of biological motion and mentalizing (Frith & Frith, 1999). In a recent study, Kuhl, Coffey-Corina, Padden, and Dawson (2005) demonstrated both a lack of preference to orient to speech (vs. nonspeech sounds) and a diminished ability in speech discrimination in preschool children with autism. Furthermore, these two abilities were directly associated with one another in the sample of children with autism. Whether the lack of social salience of voices causes or is a consequence of abnormal speech discrimination remains to be determined. Either way, lack of attention to voices in the early years may also have a negative impact on language learning in children with autism, and further work on speech and sound processing in individuals with autism is much needed.

COMMON NEURAL BASES FOR IMITATION AND LANGUAGE

Since the first report that a brain system, dubbed the "mirror neuron system," was activated in the area F5 of monkey premotor cortex both when a goal-oriented action is performed and when the same action is observed (Rizzolatti, Fadiga, Gallese, & Fogassi, 1996), there has been surge of empirical studies and theoretical accounts of this phenomena in apes and in humans (for reviews, see Decety, Chapter 11, this volume; Rizzolatti & Craighero, 2004; Williams & Waiter, Chapter 15, this volume). Further evidence has been forthcoming that the human analogue of F5, Broca's area (Brodmann area 44), along with other areas of the right anterior parietal cortex, serves a mirror neuron function in both human and nonhuman primates, in that there are neurons that are activated both when observing and performing the same spe-

cific actions (see Decety, Chapter 11, this volume). Building on theories that postulate that speech evolved from gestural communication (e.g., Armstrong, Stokoe, & Wilcox, 1994; Corballis, 2002), Rizzolatti and Arbib (1998) developed a theory that the mirror neuron system is the neural system from which language evolved. This has been more fully articulated by Arbib (2005).

Rizzolatti and Arbib (1998) and Arbib (2005) suggest that when actions-on-objects are observed, information is processed simultaneously through the dorsal stream (where the visuospatial qualities of the object and associated action are processed) and ventral stream processes where the familiarities ("knowledge" or semantics) of the object observed actions are understood. Arbib suggests that the two streams are integrated within F5/Broca's area. Further information about biological motion and intentional action is processed through the STS and inferior parietal area where intention can be attributed to the action. Arbib suggests that the mirror neuron system would first be used to imitate actions-on-objects involving the development of semantic knowledge associated with an action repertoire. This would lay the foundations for action imitation in the absence of the objects themselves leading to pantomime and gestural communication. This system then increasingly incorporated facial and oral action to evolve speech.

Therefore, according to this model, language evolved atop of a neural system that first served a reach-to-grasp function, then an imitation, a gestural communication, and pantomime function before, most recently, serving a spoken language function. If this model is correct, then language develops using the same imitative processes. New words are understood in terms of their associated "affordances" and intentions. They are assimilated into the repertoire through a self–other matching process that relates their use in the observed context to their use in the preexisting repertoire.

There is good evidence that language development is dependent on the "mirror neuron" system. Broca's area was well established as a brain region involved in various aspects of language processing from studies of patients with brain lesions, long before the neuroscience revolution of the 1990s, with lesions to Broca's area causing a characteristic aphasia of speech output with relatively conserved comprehension (Geschwind, 1970). However, there is also evidence that Broca's area is involved in the production and recognition of motor actions. Left-hemisphere brain damage causes apraxia, and an inability to copy novel actions can accompany aphasia (Goldenberg & Strauss, 2002). There is also convergent evidence that Broca's area is involved in the production of sign language and lexical retrieval for both signed and spoken language, although its role in sign language comprehension is less certain (Corina et al., 1999).

The suggestion that the mirror neuron system serves imitation, gestural communication, pantomime, and language leads perhaps obviously to the idea that it might lie at the heart of autism. The functioning of this system in individuals with autism is now under investigation and may yield evidence for a

brain basis for some of the characteristic social impairments of autism (Williams, Whiten, Suddendorf, & Perrett, 2001, Williams & Waiter, Chapter 15, this volume).

Williams (2005) suggests that Arbib has misplaced his emphasis on the object-oriented as opposed to the social functions of language in developing his model:

> During early hominid evolution, the representations being pantomimed through gestural communication (including facial expression) would have been concerned with mental states, including feelings and desires. Facial and manual gestures were being used by individuals to express both their own feelings, and what they thought others were feeling. (p. 147)

IMITATION AND LANGUAGE IN DIFFERENT CLINICAL GROUPS

This raises one question that has been little studied. Is there something different about the imitation abilities, or the structure and functioning of neural circuits that are recruited in imitation and social cognition, in those individuals with autism who do not have delayed language development, in particular children with Asperger syndrome? Williams and colleagues (2001; Williams & Waiter, Chapter 15, this volume) suggests that there may be further brain areas that serve "mirror neuron" functions that do not involve language. Frontal areas such as that which Williams and colleagues identified as serving a self–other matching function in joint attention autism may be an example of such an area.

Experimental studies will have to be designed to test such questions and if possible using prospective designs with early diagnosed children with autism spectrum disorders, comparing early versus late talkers. This will be important to avoid the ceiling effects of simple imitation tasks due to the likely advanced IQ of the children with autism with better language skills. One possibility is that the brain basis for imitative impairment might be different according to the IQ and language abilities of the group with autism studied. This might explain the intriguingly discrepant findings from two recent structural brain studies that used very similar methodology. Boddaert and colleagues (2004) showed that STS affected the lower-ability group, whereas Waiter and colleagues (2005) found the higher-functioning group to show gray matter differences in frontal and ventral temporal cortex.

Another piece of evidence that links language and imitation is the recent discovery that children with specific language impairment (SLI) also have motor coordination, praxis and imitation impairments. In one study, even children with intact motor abilities as measured by the Movement Assessment Battery for Children (Movement ABC; Henderson & Sugden, 1992) were found to be as impaired as children with developmental coordination disorder (DCD) in the production of meaningful, representational gestures (Hill, 1998;

Powell & Bishop, 1992; see Hill, 2001, for a review). The types of errors made in such tasks by children with SLI included "spatial orientation" errors where the mapping between the gesture demonstrated and that produced is impaired, suggesting that intermodal matching of the motor action seen and the motor action planned and produced is impaired (Hill, Bishop, & Nimmo-Smith, 1998). Given the evidence (reviewed earlier) for a crucial role of mirror neuron systems in language, imitation, and motor control abilities, developmental neuroscientific approaches to research might be able to establish whether abnormalities in the structure or function of this brain region play a role in the genesis of SLI. Intriguingly, there is also evidence that the genetic risk for susceptibility to SLI might overlap with that for motor impairment, thus tying speech and motor development together even further back in the pathway from genes to brain development to behavior (Bishop, 2002).

CONCLUSIONS: NEURAL VERSUS SOCIAL APPROACHES TO THE IMITATION DEFICIT IN AUTISM

In autism we know at a behavioral level that imitation abilities are associated with language abilities, with several studies demonstrating that early imitation competence predicts later language competence (Charman, 2003; Charman et al., 2003; Stone et al., 1997; Stone & Yoder, 2001; see Williams et al., 2004, for a review). There is also good evidence that vocal and gestural imitation are both longitudinally associated with language development (Carpenter, Nagell, & Tomasello, 1998; Hepburn & Stone, Chapter 13, this volume; Masur & Rodemaker, 1999). We know that imitation and language abilities develop at a delayed pace in autism. What we do not know is whether these associations hold for the *same reasons* as in typical development or whether a *different cognitive mechanism* is at work. Further delineation of the brain systems that are recruited for different types of real and imagined imitated actions (on objects, of gestures, of emotional expressions) will be required in order for us to test out some of the provocative but potentially illuminating hypotheses that emerge from the active inquiry into the roots of imitation in a diverse range of scientific fields.

For example, in autism is imitation and language mediated at a neurophysiological level by the same mirror neuron brain systems as in typical development or might alternative neural systems be recruited over development for such purposes? Alternatively, are the same systems recruited but their operation is disrupted due to imprecise representation or slow or reduced capacity processing? Neuroimaging is making it possible to delineate differences between brain systems serving mimicry, goal emulation, and intention reading that will make it possible to see how these functions are differentially affected in autism.

There is also considerable remaining work to be done in terms of the experimental study of imitation in autism. Do children with autism with intact

structural language development have a better facility for imitation of gestures and words? Can intervention programs that focus on the development of gestural, emotional, and vocal imitation improve language ability in children with autism? The fact that impairments in social motivation and social communication skills are central to autism means that the study of imitation abilities might yield evidence of where the fundamental impairment that underlies the disorder is seated. For example, does impoverished social motivation lead to impairments in processing speech sounds or does a basic impairment in processing speech sounds reduce social motivation (Kuhl et al., 2005)?

We need to pursue uncovering the underlying impairments behind the imitation deficit in autism using both the neural–cognitive and the social–ecological approaches. We can hope that the next 10 years of research yield some findings that will enable us to understand as well as to ameliorate the imitation and social communication deficits in autism.

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