CHAPTER 12

Imitation in Autism Spectrum Disorders

GIACOMO VIVANTI AND ANTONIA HAMILTON

There is a growing body of literature documenting abnormalities in different types of imitative behaviors in autism spectrum disorders (ASDs). As imitation appears to play a critical role in development (Hurley & Chater, 2005; Meltzoff & Prinz, 2002), research in this area has the potential to provide crucial insight into the mechanisms underlying learning difficulties as well as social-cognitive, communicative, and motor disturbances in this population (Carpenter & Tomasello, 2000; Rogers & Williams, 2006).

Difficulties in imitation passed unnoticed by Leo Kanner (1943) and Hans Asperger (1944), although both of their seminal descriptions of autism make reference to a lack of spontaneous learning from others in their patients. The first study that specifically addressed imitation abilities in autism was published in the 1970s (DeMyer et al., 1972); in the following decades interest in the topic increased exponentially, with more than 100 research studies published in the first years of 2000 (Sevlever & Gillis, 2010). Despite the abundance of data generated by such a research effort, there is still remarkable controversy over a number of critical issues, including (1) whether imitation deficits are universally present in autism, (2) whether there is a profile of intact and impaired imitative abilities that is specific to autism, and (3) whether imitation difficulties are cause, consequence, or comorbid features of the core impairments in autism.

In the present chapter, we review data on the development of imitation skills in autism, and consider different theories that could account for abnormal imitation performance. First, we describe the roles of imitation in development and the different strategies that might be used to copy others' behavior, we will then review the literature on imitative behavior in children with ASD, and finally we analyze the possible neurocognitive mechanisms underlying imitative difficulties in ASD, adopting a developmental and neuropsychological perspective. We also discuss remediation strategies focused on imitation.

ROLES OF IMITATION IN DEVELOPMENT

In one of his seminal works on cognitive development, Lev Vygotsky states that imitation is "one of the basic paths of cultural development of the child" (1931/1997, p. 95), emphasizing how children, by imitating adults, can perform tasks that are beyond what they can independently achieve. The role of imitation as a tool for the acquisition of knowledge was detailed in Bandura's social learning theory (1977) and subsequently supported by numerous empirical studies (see Hurley & Chater, 2005). Imitation also serves a social function: Across developmental stages and cultures, humans tend to engage in imitative behaviors in order to establish and strengthen affiliative bonds (Chartrand & Bargh, 1999; Nadel, Baudonniere, & Fontaine, 1985; Over & Carpenter, 2012; Uzgiris, 1981, 1984).

The natural course of imitation development seems to involve an early stage during which infants are capable of a limited number of imitative responses (Heimann, Nelson, & Schaller, 1989; Jones, 2009; Legerstee, 1991; Meltzoff & Prinz, 2002), followed by the emergence and rapid consolidation of synchronic imitation during dyadic exchanges between 18 and 24 months (Nielsen, Suddendorf, & Dissanayake, 2006; Trevarthen, 2001). The subsequent increase in frequency and complexity of imitative behaviors reflects the development of progressively more sophisticated cognitive and social abilities. Indeed, during preschool years, children organize their imitative behavior both on the basis of *rational* considerations (e.g., they imitate actions when they are the most efficient means in pursuing a goal, given the constraints of the situation) and *affective* ones (e.g., they are more likely to imitate actions when they experience social connectedness with the model; Bekkering, Wohlschlager, & Gattis, 2000; Buchsbaum, Gopnik, Griffiths, & Shafto, 2011; Carpenter, 2006; Gergely, Bekkering, & Kiraly, 2002; Nielsen, 2006). Imitation continues to be a central feature in adult social behavior, with research showing that adults copy others' actions both in order to acquire knowledge and to promote feelings of interpersonal closeness (i.e., a desire to conform or to be like others; Henrich & Boyd, 1998; Lakin & Chartrand 2003; Tomasello & Moll, 2010).

The importance of imitation in cultural learning and social-affective relatedness is supported by empirical research showing that early imitative abilities are concurrently associated with social engagement (Masur, 2006; G. S. Young et al., 2011) and predictively associated to nonverbal communication (Heimann et al., 2006), language development (Bates, Bretherton, & Snyder, 1988; Rose, Feldman, & Jankowski, 2009; see also McEwen et al., 2007), social understanding (Olineck & Poulin-Dubois, 2009), and cognitive skills (Strid, Tjus, Smith, Meltzoff, & Heimann, 2006). Thus, imitation is a core human skill, which is critical for the development of both social interaction and practical knowledge.

Types of Copying Behaviors and Tasks to Assess Them

In the scientific study of imitation, it is important to distinguish different types of copying behavior, because different ways of copying others' actions might serve different functions and reflect distinct underlying processes. Recent contributions from comparative psychology have helped to define a taxonomy of copying behaviors (Byrne & Russon, 1998; Want & Harris, 2002) involving the following categories:

1. *Social enhancement*. This phenomenon occurs when the presence of another individual performing an action leads the observer to engage in a different action that would not have otherwise occurred. For example, seeing someone pick up a mug of tea might lead the observer to pour milk into her own tea. The action itself is not copied and the goals might be different but the action occurred as a consequence of observing another individual's behavior.
2. *Stimulus enhancement*. Stimulus enhancement occurs when the observer's attention is drawn to a particular stimulus (or location) by another individual, increasing the probability that the

observer performs a specific action on that stimulus (or that location). For example, the observer might decide to go into a shop to buy something after noticing someone who is leaving the shop with an ice cream in his hands. The action itself is not copied (i.e., the demonstrator is leaving the shop, while the observer enters the shop) and the goals can be different (the observer might decide to buy an item that differs from the demonstrator's), but the observer chose to act on a specific stimulus/location (in the example, the shop) as a consequence of observing the demonstrator acting on the same stimulus/location.

3. *Emulation*. Emulation occurs when the observer copies the goals or the products of an action, but not the means used to achieve the goals. For example, an actor lifts books into a box one at a time; the observer later uses two hands to place a stack of books into the box. This kind of copying involves high fidelity with regard to the goals (the observer wants to achieve the exact same end state achieved by the demonstrator) and low fidelity with regard to the means (different motor acts are used to achieve the same goals).
4. *Imitation* (a.k.a., *true imitation*). Imitation, often called true imitation in comparative literature (Byrne & Russon, 1998; Thorpe, 1956) involves copying both the means and the goals of the actions. For example, the observer learns how to grasp food using chopsticks by replicating the motor acts performed by the demonstrator. This kind of learning involves high fidelity to both observed motor actions and goals.
5. *Mimicry* (a.k.a., *automatic imitation*). Mimicry occurs when the observer spontaneously and unintentionally matches the bodily movements of a model (Moody & McIntosh, 2006). For example, when seeing a happy or a sad facial expression, we may partially match that expression.

These different strategies involve different levels of complexity and require attention to different aspects of the demonstrator's actions. A key distinction here is the difference between the goal of an action and the means by which the goal is achieved. Emulation involves copying a goal, mimicry involves copying the means of an action, while true imitation requires copying of both goals and means (Hamilton, 2008). Another key distinction involves the function of the different copying behaviors. Recent research suggests that mimicry is often driven by the desire to affiliate with or relate to another person (Lakin & Chartrand, 2003) rather than by the desire to learn about objects, whilst emulation appears to reflect an interest in the product and instrumental function of the demonstration (Call, Carpenter, & Tomasello, 2005; Matheson, Moore, & Akhtar, 2012). Nevertheless, the different types of imitation might not be necessarily associated with a clearly distinct function, but rather reflect an interplay between social and instrumental learning processes (Godman, 2012; Uzgiris, 1981).

Different tasks used to study imitation in child development and in ASD put different amounts of emphasis on these different types of imitation. Classifying tasks according to the preceding taxonomy is helpful in defining which aspects of imitation are easy or hard for individuals with autism. Some tasks examine imitation toward a goal or object, or contrast this with imitation of actions that are not directed toward a goal or object. Copying actions on objects (often defined as transitive actions) can be achieved by true imitation, emulation, or stimulus enhancement, as the appreciation of the end state of the demonstrated action (e.g., a box is open) or the specific affordance of the object might be sufficient to elicit a behavior in the observer that is similar to one used by the demonstrator (removing the lid from the box).

Studies of imitation have also compared meaningful and meaningless actions. This factor of meaning is almost inevitably confounded with familiarity—meaningful actions are also often familiar to the participant and may likely have been performed before, while meaningless actions are often novel. Tests of true imitation in the comparative literature almost always use novel (meaningless) actions to ensure that responses are imitative rather than stimulus enhancement.

The meaning or familiarity of an action can be varied independently of object use, because it is possible to demonstrate both meaningful and nonmeaningful actions with and without objects. For example, some imitation paradigms included nonmeaningful actions on objects, that is, transitive actions that do not carry a semantic meaning (e.g., using a lint brush to lift some Play-Doh). The use of pantomime actions, where an actor pretends that an object is present (e.g., pretend to brush your teeth) is also found in autism research. Pantomime actions reduce the problem that participants might just use the object in the most natural way, but the use of pretend might cause difficulties for children with autism independent of their imitation skills. Other imitation paradigms aim to evaluate whether imitative difficulties in autism reflect difficulties in the social versus instrumental function of imitation by manipulating the social demands involved in the task. For example, in some tasks imitation is explicitly demanded in the task instructions, while in others is spontaneously elicited by the social situation and context.

In the next section of this chapter, we review the findings on imitation abilities in ASD across this variety of imitation tasks and processes.

IMITATION IN ASD: FINDINGS

Research in the field has mainly focused on two somewhat different aspects of imitation in ASD, namely, the frequency of spontaneous imitation and the accuracy of imitation performance.

Frequency of Spontaneous Imitation

Spontaneous imitative behavior in individuals with ASD has been investigated using systematic naturalistic observations, parent questionnaires, or paradigms involving nonspecific prompts, (e.g., the demonstrator pats a teddy bear and then gives the teddy to the participant, saying, "You can play"). Most studies document lower rates of spontaneous imitative behavior of actions on objects and gestures in children with ASD, when compared to typically developing or developmental age-matched control groups (Charman, et al., 1997; Colombi, et al., 2009; Dawson & Adams, 1984; DeMyer, et al., 1972; Ingersoll, 2008a; Knott, Lewis, & Williams, 2007; Lord, 1995; Lord, Storoschuk, Rutter, & Pickles, 1993; Whiten & Brown, 1998). However, counter-evidence exists (Brown & Whiten, 2000; Charman & Baron-Cohen, 1994; Nielsen et al., 2012; Rogers, Young, Cook, Giolzetti, & Ozonoff, 2008). Q1

Other studies have investigated spontaneous imitation through the retrospective analysis of home videos of infants later diagnosed with autism, reporting lower rates of spontaneous imitation in the first 2 years of life (Maestro et al., 2001; Osterling & Dawson, 1994; Receveur et al., 2005; Zakian, Malvy, Desombre, Roux, & Lenoir, 2000; but see Mars, Mauk, & Dowrick, 1998). Whilst most of this research has focused on children (from infancy to preadolescence), very little is known about spontaneous imitative behavior in adults with ASD. The notion that individuals with ASD imitate others less frequently than their peers is, however, widely accepted, and many screening and diagnostic instruments include lack of spontaneous imitation as a behavioral marker of early autism (e.g., Social Communication Questionnaire, Rutter, Bailey, & Lord, 2003; Modified Checklist for Autism in Toddlers, Robins, Fein, Barton, & Green, 2001; First Year Inventory, Reznick, Baranek, Reavis, Watson, & Crais, 2007; Childhood Autism Rating Scale, Schopler, Reichler & Renner, 1988; Autism Diagnostic Interview, Lord, Rutter, & Le Couteur, 1994). Some studies have explicitly contrasted imitative behavior in elicited versus naturalistic conditions. These suggest that imitative differences in ASD are more pronounced in a spontaneous versus elicited context (Ingersoll, 2008a; see also McDuffie et al., 2007).

A different way to investigate spontaneous imitation in ASD is through the measurement of rapid and unintentional matching responses to others' actions and facial expressions (i.e., automatic imitation, or mimicry). Using fine-grained measurements of muscular activity, several studies found that individuals with ASD, compared to typically developing controls, show a reduced or delayed automatic motor mimicry response to others' bodily movements and facial expressions (Beall, Moody, McIntosh, Hepburn, & Reed, 2008; McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006; Oberman, Winkielman, & Ramachandran, 2009; Stel, van den Heuvel, & Smeets, 2008). However, other studies documented enhanced (Magnee, de Gelder, van Engeland, & Kemner, 2007) or intact mimicry responses (Bird, Leighton, Press, & Heyes, 2007; Grecucci et al., 2012; Press, Richardson, & Bird, 2010). Given that tasks, stimuli, and measurement strategies vary considerably across studies, more empirical work is needed to solve inconsistencies and clarify the nature of motor mimicry abnormalities in ASD.

Accuracy of Elicited Imitation

Most of the research studies investigating imitation in autism have looked at the accuracy of imitation performance in paradigms involving explicit instructions (e.g., the demonstrator shows an action and then says, "Now you do it" or "Your turn"). The to-be-imitated actions are characterized by the presence or absence of an object (actions on objects versus gestures), by whether the demonstrated actions are directed to a goal (meaningful versus nonmeaningful actions), and whether the actions are simple or complex (single versus sequential actions).

Infants and Toddlers

Using a prospective design, Zwaigenbaum and colleagues (2005) documented difficulties in the imitation of actions on objects in infants with ASD as young as 12 months. Similarly, G. S. Young and colleagues (2011) found difficulties in the imitation of actions on objects, gestures, and oral-facial movements in 12-month-old children subsequently diagnosed with ASD when compared to typically developing peers. However their performance was not different from that of at-risk siblings with developmental delays but no autism. In contrast, studies on toddlers have reported difficulties in imitation of actions on objects and gestures in participants with ASD when compared to both typically developing and developmental delayed peers (Rogers, Hepburn, Stackhouse, & Wehner, 2003; Rogers, Young, Cook, Giolzetti, & Ozonoff, 2010; Stone, Ousley, & Littleford, 1997).

Several studies investigated the developmental course of imitative behavior in ASD. Employing a prospective design, G. S. Young et al. (2011) showed that imitative abilities in infants with ASD improve between 12 and 24 months, following a similar developmental progression to that of typically developing children. Similarly, Poon and colleagues reported improvements in imitative behavior between 12 and 18 months (Poon, Watson, Baranek, & Poe, 2011); moreover, improvements were documented between 24 and 36 months (Stone, Ousley, & Littleford, 1997); see also Hepburn & Stone, 2006; Vivanti, Hepburn, Philofsky, & Rogers, 2009) and between the ages of 4 and 6 (Heimann & Ullstadius, 1999). However, despite these improvements over time, individuals with autism continue to exhibit imitation deficits at different developmental stages.

Older Children, Adolescents, and Adults

Studies testing older children, adolescents, and adults with ASD using elicited imitation tasks consistently report difficulties in the imitation of nonmeaningful gestures, that is, actions that do not involve objects, do not carry a specific meaning, and can only be described in terms of changes of limb postures in space (e.g., lifting the elbow above the shoulders; Bernier, Dawson, Webb, & Murias, 2007; Jones & Prior, 1985; Rogers, Bennetto, McEvoy, & Pennington, 1996; Stieglitz Ham et al., 2011; Vanvuchelen, Roeyers, & De Weerdt, 2007; Vivanti, Nadig, Ozonoff, & Rogers, 2008). These findings are consistent across developmental age and symptom severity ranges. Given that the familiarity with the demonstrator's goals and means cannot be exploited in this type of task, performance in imitation of nonmeaningful gestures provides the most rigorous test of impairment in true imitation.

Imitation of nonmeaningful oral-facial movements (e.g., lip protrusion, lifting eyebrows while blinking eyes) was also found to be impaired in individuals with ASD across functioning levels and age ranges (Bernier et al., 2007; Freitag, Kleser, & von Gontard, 2006; Page & Boucher, 1998; Rogers et al., 2003). However, most studies investigating imitation of meaningful facial movements (in particular emotional expressions such as smiling, or showing surprise) found normative performance in ASD (Dapretto et al., 2006; Loveland et al., 1994; Stel et al., 2008; but see Grecucci et al., 2012; Grossman & Tager-Flusberg, 2008). This pattern is consistent with the idea that copying action/gestures with a meaning might be easier than copying nonmeaningful movements for individuals with autism.

Research investigating the imitation of meaningful gestures (i.e., conventional gestures that carry a meaning, such as thumbs up or a hammering action without a hammer), also documented ASD-specific deficits across chronological and mental age ranges (Beadle-Brown, 2004; Dewey, Cantell, & Crawford, 2007; Hammes & Langdell, 1981; Mostofsky, et al., 2006; Smith & Bryson, 2007). Nevertheless, several studies that compared performance in different types of tasks suggested that individuals with ASD imitate meaningful gestures better than nonmeaningful ones (Cossu et al., 2012; Oberman, Ramachandran, & Pineda, 2008; Rogers et al., 1996; Vanvuchelen et al., 2007; Wild, Poliakoff, Jerrison, & Gowen, 2011; Zachor, Ilanit, & Ben Itzchak, 2010). Notably, this pattern is seen in typically developing individuals as well (Tessari & Rumiati, 2004).

The notion that imitative performance varies depending on task type is also supported by research involving the imitation of actions on objects (e.g., pressing a button or opening a box). Several studies found that individuals with ASD, across developmental levels and age ranges, have difficulties imitating meaningful actions on objects (Bernier et al., 2007; Colombi et al., 2009; Cossu et al., 2012; Leighton, Bird, Charman, & Heyes, 2008; Rogers et al., 2010; Stieglitz Ham, 2011). Other studies, however, report intact ability to perform this type of task (Beadle-Brown & Whiten, 2004; Hobson & Hobson, 2008; Rogers et al., 1996), but some of these had results confounded by ceiling effects.

Studies employing both actions on objects and gestures often report that imitation of actions on objects is less impaired than imitation of gestures (DeMeyer, et al., 1972; Ingersoll & Meyer, 2011a; Q2
Vivanti et al., 2008; Zachor et al., 2010). One potential confound in this type of paradigm is that, unlike gestures, actions on objects can sometimes be copied by relying on different social learning strategies (e.g., social enhancement or emulation as opposed to true imitation). For example, if the demonstrator opens a box, the imitator might notice the box and act on it according to the specific affordance or of the object (a closed box invites the action of opening), or to the familiar routine associated to the object (e.g., rocking a baby doll). Actions on objects are also constrained by the features of the object, eliminating some degrees of freedom and scaffolding action imitation performance.

The most stringent test of true imitation of actions on objects involves the use of unconventional or novel actions that do not carry a semantic meaning (nonmeaningful actions on objects; e.g., using a brush to lift some Play-Doh). A number of studies using this type of paradigm reported impairments in ASD across age range and developmental level (Charman et al., 1997; Hammes & Langdell, 1981; Smith & Bryson, 2007). One particularly interesting test of imitation examined how children imitated novel actions on objects (e.g., scrape a stick along a block to make a sound) and whether they imitated the style in which the action was performed (gently or harshly) (Hobson & Lee, 1999; see also Hobson & Hobson, 2008). In the experiment, children with autism accurately imitated the object use and goals but did not imitate the style of the action.

A number of other studies also demonstrate the priority of action goals and outcomes in imitation in ASD. In two different studies, children with autism were successfully able to perform Meltzoff's incomplete intentions task (Aldridge, Stone, Sweeney, & Bower, 2000; Carpenter, Pennington, & Rogers, 2001), in which the child sees an adult attempt but fail to perform a simple action, and then the child is given the chance to perform the same action successfully. Both typical and ASD children imitate the action even though they never saw the adult achieve the goal. Similarly, both children with an ASD and children with typical development show the same characteristic pattern Q3 of goal-directed imitation (Hamilton, Brindley, & Frith, 2007). In this task, the demonstrator touches a dot on the right with her left hand (an inefficient action) but both typical and autistic children perform the more efficient action of touching the dot with their right hand, thus copying the action goal but not the means. In another experiment, children with ASD were successful in copying the arbitrary rules to achieve a reward in a categorization game (Subiaul et al., 2007), thus showing sensitivity to the goal/meaning underlying the observed motor actions. Other studies show that children with ASD are more likely to imitate actions on objects that result in relevant/motivating feedback (Ingersoll, Schreibman, & Tran, 2003; Rogers, et al., 2010).

Recent evidence suggests that the tendency to focus on action goals in this population may be driven to some extent by action affordances. In a study based on eye tracking (Vivanti et al., 2011), participants had to complete actions on objects after watching videos in which the demonstrator starts but does not finish the action. The study showed that individuals with ASD tended to complete actions according to the affordances suggested by the objects' properties, rather than relying on the demonstrator's intention (which was conveyed by facial and gaze cues). Difficulties in integrating the social cues provided by the demonstrator are also reported in other studies (e.g., D'Entremont & Yazhek, 2007).

Another dimension that was explored by a number of studies concerns the motor complexity/demand of the demonstrated actions (i.e., single versus sequential actions). The general pattern emerging from available literature is that individuals with ASD, across age range and developmental level, find it more difficult to imitate sequences of actions than singular actions (Libby, Powell, Messer, & Jordan, 1997; Rogers et al., 1996; Smith & Bryson, 1998; Vanvuchelen et al., 2007). Some studies also document reversal errors during imitation in ASD (i.e., imitation of actions with reversed direction of movement; Carpenter, Tomasello, & Striano, 2005; Stieglitz Ham et al., 2011; Ohta, 1987); however, other studies did not replicate this finding (Vanvuchelen et al., 2007).

Another important issue concerns the universality of the imitation deficit in ASD. If imitation deficits are universal in ASD, these deficits must be present in every individual with ASD, regardless of cognitive ability or severity of ASD symptoms. Remarkable heterogeneity in imitation performance in ASD is reported by a number of studies (e.g., Hobson & Lee, 1999; Rogers et al., 2010; Salowitsz et al., 2012; Vanvuchelen, Roeyers, & De Weerdt, 2011; Vivanti et al., 2011), suggesting that imitation difficulties are present in many but not all individuals in the spectrum. For example, in the study by Vanvuchelen and colleagues involving a large sample of toddlers with ASD (2010), imitation deficits were present in around 70% of participants. As most published studies focus on group differences, without reporting on individual variations, more research is needed to gain further knowledge on the issue of universality.

Developmental Correlates of Imitation in ASD

As originally suggested by Rogers and Pennington (1991), the importance of research on imitation in ASD might extend beyond the study of imitative ability per se, as many developmental processes and skills that are relevant in ASD (including communicative, social-cognitive, emotional, and motor-executive abilities) appear to be linked with imitation. A number of studies, for example, found concurrent and predictive correlations between imitation and language in children with ASD (Charman, et al., 2000; Dawson & Adams, 1984; Ingersoll & Meyer, 2011b; McDuffie et al., 2007; Stone & Yoder, 2001; Toth, Dawson, Meltzoff, Greenson, & Fein, 2007; but see Rogers et al., 2003). Other studies found imitative abilities to be correlated with functional and symbolic play (Libby, Powell, Messer, & Jordan, 1997; Stone et al., 1997; Vivanti, Dissanayake, Zierhut,

& Rogers, 2013), joint attention (Carpenter, Pennington, & Rogers, 2002; Ingersoll & Schreibman, 2006; Rogers, et al., 2003), severity of autistic symptoms (Rogers et al., 2003; Ingersoll & Meyer, 2011; Zachor et al., 2010), and measures of social reciprocity (McDuffie et al., 2007; G. S. Young et al., 2011), cooperation (Colombi et al., 2009), and theory of mind (Perra et al., 2008; but see Charman, 2000). Concurrent correlations between imitation and different measures of praxis and motor abilities are also frequently reported (Mostofsky et al., 2006; Salowitz, et al., 2012; Smith & Bryson, 1998; Vanvuchelen et al., 2007).

Summary

In summary, current available evidence suggests that individuals with ASD, as a group, imitate others less frequently and less accurately from infancy, at least when compared to typically developing peers. Despite gains over time in imitative abilities, they continue to show impairments throughout the lifespan. These impairments are more obvious in tasks that measure true imitation, that is, copying the demonstrator's actions and goals without relying on knowledge about the outcomes of the action or the function/use of materials involved in the demonstration. In contrast, individuals with ASD seem to imitate better when tasks involve objects, when they are familiar with the materials involved in the task, when they understand the demonstrator's goals, and when they are interested in the outcome of the action. Moreover, imitation of single actions seems to be easier in this population than imitation of sequences of actions. Differences in imitative behavior appear to be associated to differences in social, communicative, as well as motor skills in this population; however, the nature of these associations is still not clear. Imitative difficulties are unlikely to play a causal role in autism, given that not all individuals in the spectrum show an imitation impairment and at-risk siblings who do not develop autism show a comparable deficit in imitation in infancy (G. S. Young et al., 2011).

In the following section, we review the possible causal mechanisms underlying this complex pattern of imitative abnormalities in ASD.

THEORIES OF IMITATION

In order to understand imitation behavior, it is necessary to consider the underlying cognitive processes that take place during imitation. In information processing terms, imitation is not a single entity, but relies on multiple domain general processes that may contribute to other tasks as well. Here we describe a model of the cognitive components needed for imitation, and then assess how different theories of autism have placed the impairment in different components.

Our earliest models of imitation derive from studies of neuropsychological patients. Rothi & Heilman (1997) proposed a dual route model of imitation, and current research largely supports their ideas. An up-to-date form of the model was presented by Tessari and Rumiati (2004) based on studies of typical adults. In this model (Figure 12.1), an observed action must first be encoded visually (Figure 12.1a). Brain imaging studies link this to MTG/STS (Downing, Peelen, Wiggett, & Tew, 2006). There are then two possible ways in which the action can be processed. A familiar, meaningful action can be matched onto an existing semantic or action knowledge representation (Figure 12.1b). For example, seeing a person pretend to brush her teeth engages the idea of a toothbrush and the motor knowledge of how to brush one's own teeth. This semantic representation can then provide an input to the motor system, allowing the participant to engage the familiar motor plan for teeth brushing and to produce the action (Figure 12.1c). This type of action knowledge and motor planning is commonly associated with IPL (Buxbaum, Kyle, & Menon, 2005; Grafton & Hamilton, 2007).

However, typical individuals also have the ability to imitate actions that are novel and have no preexisting semantic representation. In this case, the visual representation of the observed action must be mapped directly to the motor system. For example, when seeing an unfamiliar hand gesture, the observed shape of the actor's hand must be mapped onto the participant's own hand to allow the participant to produce the same action (Figure 12.1d). In the case of both familiar and

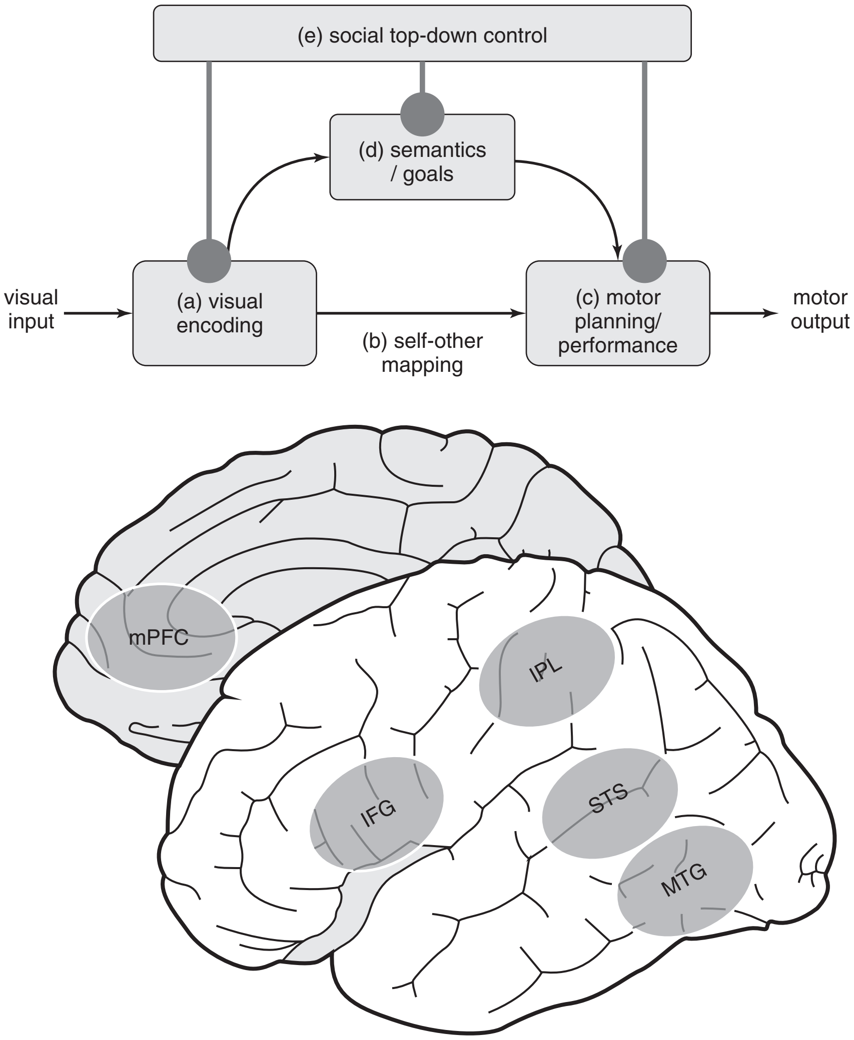

Figure 12.1 Imitation processing and brain systems involved in imitation. (a) Visual encoding of actions involves MTG (middle temporal gyrus) and STS (superior temporal sulcus). (b) Self–other mapping has no clear brain localization. (c) and (d) Motor performance and motor semantics both involve IPL (inferior parietal lobule) and IFG (inferior frontal gyrus), which together comprise the mirror neuron system. (e) Top-down control of imitation involves medial prefrontal cortex (mPFC).

unfamiliar actions, the participant must then have an intact motor system in order to execute the action and show successful imitation (Figure 12.1c). The core of this model (Figure 12.1b, c, and d) comprises the human mirror neuron system (MNS; Rizzolatti & Craighero, 2004).

There are two possible routes through this system: A semantic route allows comprehension of goal and action meaning to contribute to imitation, while a direct route allows imitation of meaningless gestures. Using both routes together is likely to be necessary for true imitation. This dual route model of imitation has been augmented and elaborated in some recent works (Buxbaum & Kalenine, 2010), but the basic idea of two possible information processing streams for imitation remains a powerful way to understand imitation in a variety of neuropsychological conditions.

The two or more imitation routes present in the MNS (Figure 12.1 a, b, c, and d) together comprise a fundamental visual-motor processing stream, in which visual inputs can be translated into motor outputs. Anatomically, this visuomotor stream is embedded within a much more general visual-motor processing system that receives all visual inputs (not just actions to imitate) and plans and executes appropriate motor responses (Cisek & Kalaska, 2010). The behavior and responsiveness of this system is determined to a large extent by associative learning based on the individual's past experience, rather than being innately specified (Heyes, 2011). This implies that the mirror neuron system is not dedicated purely to imitation but should be considered as part of a broader, more general visual-motor system.

While this dual-route, neuropsychology-based model of imitation has a considerable explanatory power, it has it has recently become clear that there is more to everyday imitation than just this. Typical children and adults imitate far more than they need to just to achieve their everyday goals of moving through the world. Typical toddlers show overimitation (Over & Carpenter, 2012), copying even causally unnecessary components of action sequences, whereas apes do not (Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009). Adults imitate one another's gestures and mannerisms during social interactions, a phenomenon often described as the chameleon effect (Lakin & Chartrand, 2003). The frequency of these additional imitation behaviors is strongly modulated by social cues. For example, toddlers and children overimitate more when they are socially engaged (Brugger, Lariviere, Mumme, & Bushnell, 2007; Nielsen & Blank, 2011) and adults show more unconscious gesture imitation when interacting with someone of high social status or when they have an affiliation goal (Bandura, 1971; Lakin & Chartrand, 2003). These phenomena fall under the broad category of social imitation (Over & Carpenter, 2012).

The existence of social imitation, and the subtle control of this behavior by a variety of social signals, led researchers to augment the basic dual-route imitation model with a top-down control system (Figure 12.1e; Southgate & Hamilton, 2008; Wang & Hamilton, 2012). This system recognizes social cues (eye contact, social status, context, etc.) and based on these signals, can up-regulate or down-regulate imitation processing in the visuomotor processing stream. Neuropsychological evidence suggests that the control of imitation is likely to involve the prefrontal cortex. Patients with prefrontal damage often show echolalia or echopraxia, that is, excessive imitation of actions indicative of damaged imitation-control systems (De Renzi, Cavalleri, & Facchini, 1996; Lhermitte, Pillon, & Serdaru, 1986; Luria, 1966; Vendrell et al., 1995). Recent brain imaging studies support this notion. Brass and colleagues showed that medial prefrontal cortex is engaged when participants must inhibit their natural tendency to mimic (Brass, Derrfuss, & von Cramon, 2005). Going further, an functional magnetic resonance imaging (fMRI) study shows that eye contact enhances mimicry and that during this enhancement, medial prefrontal cortex increases its regulation of superior temporal sulcus, which provides inputs to the mirror system (Wang, Ramsey, & Hamilton, 2011). Q4
These new information processing models show how imitation behavior involves a subtle interaction of many different brain and cognitive systems. Figure 10.1 provides an overview of the major cognitive processes involved in imitation behavior in typical adults. Different theories of poor imitation in individuals with ASD have posited problems with different components of this model. We review and assess these theories, focusing on one component at a time.

Theories of Poor Visual Encoding

One possibility is that individuals with autism stumble at the first step of the imitation process, that is, they imitate less frequently and less accurately as a consequence of abnormal visual encoding of others' actions (Figure 12.1a). Two bodies of literature support this perspective: first, studies documenting reduced attention to others' actions, and second, studies suggesting atypical perceptual strategies in this population. Individuals with ASD show atypical patterns of attention to both social (Klin, Jones, Schultz, Volkmar, &

Cohen, 2002; Rice, Moriuchi, Jones, & Klin, 2012) and nonsocial stimuli (Anderson, Colombo, & Jill Shaddy, 2006; Sasson, Elison, Turner-Brown, Dichter, & Bodfish, 2011), as well as a lack of interest in people and their actions (Barbaro & Dissanayake, 2013; Kasari, Sigman, Mundy, & Yirmiya, 1990). It is therefore possible that children with ASD fail to imitate because they do not pay attention to actions that are demonstrated to them. This hypothesis was explicitly tested in two eye-tracking studies (Vivanti et al., 2008; Vivanti et al., 2011). Results from these studies indicate that children with autism, across chronological and developmental age groups, show no abnormalities in the amount of attention to actions that are demonstrated to them. However, a reduced attention to the demonstrator's face has been consistently reported. Importantly, this research is based on elicited imitation paradigms; no study, so far, investigated whether differences in visual attention to others' actions explain reduced frequency of spontaneous imitative behavior in this population. Abnormalities in visual encoding in ASD might not be limited to the amount of visual attention, but could possibly involve atypical visual processing (Dakin & Frith, 2005; Simmons et al., 2009). In particular, some studies documented enhanced processing of fine details (possibly at the expenses of the overall picture; Happé & Frith, 2006) and difficulties in the analysis of motion coherence and biological motion (Pellicano, Gibson, Mayberry, Durkin, & Badcock, 2005). However, a recent large-scale study suggests teenagers with ASD process biological motion just like typical individuals (Jones et al., 2011). The nature of these perceptual phenomena is still debated, and there is still no consensus on the role that visual processing abnormalities might play in the development of ASD symptoms (Simmons
Q5 et al., 2009; Mottron, Dawson, Soulieres, Hubert, Burack, 2006). No study so far has addressed the possible role of visual processing abnormalities in imitation abilities in ASD.

Overall, eye-tracking research rules out the idea that imitation difficulties in ASD occur as a consequence of lack of attention to the model. It is reasonable to suspect that abnormalities in visual processing of others' actions, both at the quantitative and qualitative level, might affect imitative behavior in ASD. Nevertheless, the idea of a bias toward the subcomponents of the visual stimulus (the demonstration's action units) at the expense of the global meaning of the action (the demonstrator's goal) does not fit with the pattern of strengths and weakness in imitation emerging from the literature, which shows better imitation of goal-directed versus meaningless actions in this population. Furthermore, the initial finding of difficulties in processing biological motion in ASD was not successfully replicated in subsequent research (Jones et al., 2011). More research is needed to investigate the role of atypical visual input processing in imitative performance in ASD. However, available evidence suggests that atypical visual processing of the input does not provide a satisfactory explanation for the range of phenomena documented in ASD imitation research.

Theories of Failed Direct Self–Other Mapping

In their 1991 influential paper, Rogers and Pennington proposed that the imitative deficit in ASD might reflect a specific difficulty with "forming and coordinating specific social representations of self and other" (i.e., self-other mapping) (Figure 12.1b). The construct of self–other mapping, inspired by the work of Stern (1985), refers to the ability to register/appreciate correspondences between own and others' actions (as well as mental and affective states). This process, as reflected in early imitative and affective exchanges, is thought to support the development of a range of social-cognitive skills such as joint attention, symbolic play, and theory of mind, so that an impairment at this level would result in a series of negative developmental sequelae. An updated version of this model proposed by Williams and colleagues in 2001included the suggestion that the self-other mapping process might be implemented by the MNS, and consequently, that difficulties with self–other mapping might originate from a MNS dysfunction (broken mirrors theory; Williams, Whiten, Suddendorf, & Perrett, 2001).

The mirror neuron system is located in the human inferior parietal and inferior frontal gyrus, and, in typically developing individuals, responds to the self-execution of a given action as well as to the observation of a similar motor act performed by others (Rizzolatti & Craighero, 2004). According to a number of scholars, this distinctive property reflects the implementation of a direct mapping between observed and performed actions, which allows the observer to understand others' actions as if he or she would be doing a similar action (Gallese, 2006). Based on these claims, we illustrate the self–other mapping in Figure 12.1 in terms of the basic link between a visual representation of an action and the motor plan needed to perform the action. After Williams et al.'s original proposal, different versions of the broken mirror theory of autism have been described by several groups (Gallese, Rochat, & Berchio, 2012; Iacoboni & Dapretto, 2006; Ramachandran & Oberman, 2006; Rizzolatti, Fabbri-Destro, & Cattaneo, 2009; Sinigaglia & Sparaci, 2010; Williams, 2008), all sharing the idea that in autism, there is an absence or impairment of a fundamental, low-level mapping between the visual representation of an action performed by another person and a mirrored representation of that same action in the observer's own motor system. This, in turn, disrupts the process of self–other correspondence that enables understanding and reproduction of observed actions.

One specific prediction of the broken mirror model is that mimicry, being a behavioral index of self–other mapping, would be impaired in ASD. As discussed earlier, mimicry in ASD is reported to be reduced in some studies, while other studies report intact or enhanced mimicry; therefore more research is needed to clarify this issue (are all the studies equally well executed?). Another prediction of the model is that difficulties in imitation would be associated to difficulties in other abilities that are supposedly implemented by self–other mapping (or mirroring) mechanism. These include affect sharing, symbolic play, language, and joint attention (in the original Rogers & Pennington model; see also Q6 Pennington, Williams, & Rogers, 2006) as well as goal understanding, theory of mind and empathy (according to most versions of the broken mirrors model; see Iacoboni, 2009). A number of studies report correlations between imitation and measures of language, joint attention, affect, play, and theory of mind, suggesting that these constructs might reflect some common underlying factors (e.g., Colombi, et al., 2009; Ingersoll & Meyer, 2011;). Nevertheless, not all studies confirm these associations (e.g., Rogers et al., 2003; Johnson, Gillis, & Romanczyk, 2012), and more research is needed to understand the causal structure among these variables from a developmental perspective.

A further prediction from the broken mirror model is based on the claim that the mirror neuron system is mainly concerned with goal understanding (Rizzolatti & Sinigaglia, 2010). This implies that participants with autism should have particular difficulties understanding and imitating action goals (Hamilton, 2009). This prediction appears to be inconsistent with the data indicating better imitation of actions with goals versus actions without goals, and better performance in tasks involving emulation versus imitation in ASD (see findings section).

A different approach for testing the broken mirrors model involves the measurement of MNS integrity using neuroimaging techniques during imitation tasks. Surprisingly, most of the studies on MNS activity in ASD have used action-observation tasks rather than imitation tasks, providing little information on the actual role of the putative MNS dysfunction in imitation. The few studies testing MNS activity during imitation task yielded mixed findings. A magnetoencephalography (MEG) study by Nishitani, Avikainen, and Hari (2004) found abnormal MNS activity during an imitation task in ASD. Similarly, a study by Bernier et al. (2007) found a correlation between imitation difficulties and abnormal attenuation of mu-rhythm over the motor cortex during action observation, which is considered an indicator for the action/perception coupling activity (Pineda, 2005) and a specific index of the MNS. Using the same technique, however, Fan, Decety, Yang, Liu, and Cheng (2010), failed to replicate this finding, reporting intact mu-rhythm activity in the presence of impaired imitation. Using fMRI, Dapretto et al. (2006) documented abnormal activity in the frontal component of the MNS during a facial imitation task; this, however, was not associated with imitation performance (which was reported to be intact in the study; however imitative accuracy was not actually measured). In another fMRI study Williams et al. (2006) reported reduced activity in the parietal component of the MNS during an imitation task, which was not correlated to the actual imitative performance. Given the paucity and the inconsistency of the neural processing data gathered during imitation tasks, both in ASD and typical population, more research is necessary to clarify (1) whether the MNS is actually implementing a self-other mapping (mirroring) mechanism underlying imitation and (2) whether a specific deficit in such process is the cause of the range of imitative difficulties observed in ASD. Whilst evidence for the involvement of the MNS in imitation difficulties in ASD is rather spotty (Hamilton, 2013), difficulties with the processing of self–other correspondences might not necessarily be associated with a MNS dysfunction or with a disrupted perception/action matching mechanism. Alternative interpretations of the nature and role of this process in the imitative deficit in ASD are considered in the section on theories of abnormal social top-down control.

Theories of Abnormal Motor and Sensory-Motor Disturbances

A number of studies explored the possibility that poor imitation in ASD might be caused by motor-related disturbances (Figure 12.1c, d). Motor impairments appear to be present in at least a significant subgroup of individuals with ASD and may include deficits in basic fine and gross motor skills as well as difficulties in motor planning and motor learning (Esposito & Vivanti, 2012; Gowen & Hamilton, 2012; Lloyd, Macdonald, & Lord, 2011; Silver & Rapin, 2012). The idea that imitation impairments in ASD reflect deficits in the basic motor operations involved in the execution of the observed actions is supported by studies documenting an association between motor and imitative performances (McDuffie et al., 2007; Vanvuchelen et al., 2007). However, two recent studies documented that while impaired imitation of gestures in ASD was highly correlated with impairments in basic motor control, the motor impairments did not fully account for impaired imitation (Dowell, Mahone, & Mostofsky, 2009; Dziuk et al 2007). Several other studies suggested that imitative difficulties distinguish between ASD and other diagnostic groups even when fine and gross motor difficulties are accounted for (Smith, 1998; Williams, Whiten, & Singh, 2004).

A number of studies looked at the possibility that poor imitation might be caused by abnormalities in higher motor or sensory-motor processes. Mostofsky and colleagues recently detailed a theory proposing that abnormal imitation in ASD originates from abnormal visual-motor integration (Mostofsky & Ewen, 2011). This is based on the finding that individuals with ASD show a diminished reliance on visual feedback and an increased reliance on proprioceptive feedback when learning novel movements; that is, they tend to use the input from their own internal world rather than visual input from the external world for motor learning. The strength of this bias in ASD was found to be correlated with impairments in imitation (as well as praxis and social interaction difficulties; Haswell, Izawa, Dowell, Mostofsky, Shadmehr, 2009; Izawa et al., 2012).

Overall, theories of abnormal motor or sensory-motor disturbances appear to be supported by a number of findings, including (1) evidence that dyspraxia is common in ASD (Mosconi, Takarae & Sweeney, 2011; Rapin, 1996), (2) evidence that imitation accuracy in this population decreases as the motor demand increases (e.g., in sequential versus single action imitation tasks), (3) evidence of associations between levels of motor and imitation abilities in this population, and (4) evidence of an association between imitation performance and abnormal visual-motor integration specific to ASD (Izawa et al., 2012). Nevertheless, some studies that specifically tested the role of motor versus social factors in imitation performance in ASD found evidence that social factors might be more relevant (e.g., Perra et al., 2008; Zachor et al., 2010). Moreover, neither the general motor planning nor the sensory-motor integration abnormalities hypothesis clearly account for a range of phenomena documented in literature, including evidence that individuals with ASD imitate more in elicited versus naturalistic conditions, the differences in patterns of visual attention to the demonstration, and the difficulties in imitating the affective style versus the goals of the demonstrated actions. More research is necessary to clarify the complex interplay between motor, sensory-motor, and social cognitive functions in relation to imitation in typical development and autism.

Theories of Abnormal Social Top-Down Control

The control of who and when to imitate is not trivial. There are an increasing number of suggestions that abnormal imitation in individuals with autism might be due to failure of top-down control signals or social motivational signals (Figure 12.1e). In typical children and adults, imitation is modulated by social cues such as eye contact (Wang, Newport, & Hamilton, 2011), social interactivity (Brugger et al., 2007) and social status (Cheng & Chartrand, 2003). Failure of this top-down social modulation of imitation could account for many of the imitation differences observed in autism (Southgate & Hamilton, 2008). This model has been termed STORM (social top-down response modulation), and the key claim is that basic imitation mechanisms are intact in autism, while top-down control signals are abnormal or absent in this population (Wang & Hamilton, 2012).

A parallel perspective, building on a different research approach, involves the distinction between *imitation* and *identification* proposed by Hobson (Hobson & Hobson, 2008; Hobson & Lee, 1999), which is based on the idea that a process of identification at the affective level must take place between the observer and the demonstrator for accurate imitation to occur. Hobson proposes that while motor imitation per se is intact in autism, imitative abnormalities reflect a lack of interpersonal-affective identification with others in this population (Hobson, 2010). The construct of interpersonal identification overlaps only in part with the similar notion of self–other mapping (Rogers & Pennington, 1991) as it emphasizes the importance of the propensity/drive to identify with others (supposedly impaired in ASD) rather than the integrity of the visuomotor hardware underlying copying behaviors, which is assumed to be intact (Hobson & Meyer, 2005).

Another, similar, top-down account of abnormal imitation in ASD can be derived from the social motivation theory of autism (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Dawson, et al., 2005; Mundy & Neal, 2001). According to this perspective, young children with autism, as opposed to their typically developing peers, do not experience social interactions as intrinsically rewarding and do not prioritize social stimuli over nonsocial information, thus failing to develop over time the motivation and the ability to connect to others and maintain social relationships. Evidence from social psychology suggests that unconscious imitation of others is a tool for building and maintaining social relationships (Lakin & Chartrand, 2003), so a lack of social motivation could lead to a lack of imitation. Again, this model predicts that imitation mechanisms themselves are intact in autism but are not appropriately used. One way to test this hypothesis is to study overimitation behavior (the tendency to copy unnecessary actions), which is largely socially motivated. One study found that children with autism do overimitate actions on novel objects (Nielsen, Slaughter, & Dissanayake, 2013), while a second study found that typical children overimitate actions on familiar objects but children with autism do not (Marsh, Pearson, Ropar, & Hamilton, 2013). Further study of the role of social motivation in imitation would be very valuable.

These top-down theories can provide a good explanation of abnormal imitation frequency in ASD. They account for reduced spontaneous imitation (see findings section), especially in response to social cues (Ingersoll, 2008a, 2008b) and also for increased imitation in cases such as echolalia and echopraxia (Grossi, Marcone, Cinquegrana, & Gallucci, 2013; Spengler, Bird, & Brass, 2010). In the latter behaviors, abnormal top-down signals lead to too much imitation or imitation at a socially inappropriate time. The top-down theories are particularly strong in accounting for the widely variable results found in some studies of imitation in ASD, with some studies reporting good performance and others reporting poor performance (see reviews by Hamilton, 2009, and Vivanti, 2013). For example, Hobson and Lee (1999) and Hobson and Hobson (2008) found that children with ASD were able to imitate the goal of an action but did not accurately imitate the style in which the action was performed. Top-down theories suggest that imitation of an action goal is motivated by the nonsocial desire to do the action and does not require social control signals. In contrast, imitation of the action style might only occur if the child identifies with the demonstrator or is socially motivated to engage with them. This latter type of imitation is abnormal in ASD, reflecting failure of social engagement in this population. The eye-tracking studies by Vivanti and colleagues (2008, 2011, 2013) are consistent with the idea that individuals in the spectrum might show reduced sensitivity to the social cues (in particular, referential cues) conveyed by the demonstrator's face, relying instead on the properties of the objects involved in the demonstration or on the demonstrator's actions.

However, few direct tests of the top-down theories of imitation have been conducted. A study by Cook and Bird (2012) examined how mimicry responses are modulated following a conceptual priming manipulation in high-functioning adults with autism. Typical adults show faster mimicry after they performed a task involving unscrambling of pro-social sentences, compared to priming with neutral or anti-social sentences. Adults with autism show the same level of mimicry responses across all three conditions, suggesting that top-down modulation of mimicry is abnormal in this group. Similarly, Grecucci et al. (2012) found normal mimicry of hand actions in autism but a lack of modulation of responses by the presence of an emotional facial expression. A study by Spengler and colleagues (2010) showed that individual differences in activation of medial prefrontal cortex (mPFC) during a theory of mind task predicted individual differences in the control of mimicry, within a sample of high functioning adults with ASD. This suggests that abnormalities in the control of mimicry are linked to abnormalities in brain systems linked to theory of mind, a domain where individuals with autism are known to struggle (Baron-Cohen, Leslie, & Frith, 1985; Senju, 2012). Further studies would be very valuable in testing the top-down control theory of imitation in autism in detail.

One limitation of the STORM theory is that it does not account for reduced accuracy of imitation in ASD. The top-down theory assumes that basic imitation mechanisms are intact in autism, and thus predicts that when imitation does occur, it should be accurate in ASD. There are also several aspects of the top-down theory that are not fully specified. It is not yet clear if failure of top-down control of imitation in ASD is due to difficulties in detecting social cues, or difficulties in implementing control or in a reduced motivation to engage with others. It is not clear if this top-down control applies to other social behaviors beyond imitation, and how it relates to other domains that have been implicated in ASD, including theory of mind and executive function (Pellicano, 2010). Further study on all these possibilities will be very valuable.

INTERVENTION STRATEGIES

Imitation is critical for interventions to help children with ASD because a child who can imitate has a powerful tool for both learning and socialization. A number of strategies have been developed to teach imitative skills in individuals with ASD since the 1960s (Lovaas, Freitas, Nelson, & Whalen, 1967; Metz, 1965). Strategies based on discrete trial teaching involve the use of highly structured settings and external reinforcements (e.g., food) to elicit imitative behavior in response to a predefined fixed series of stimuli. Several studies document that through these procedures individuals with ASD can learn to imitate a number of complex behaviors, including actions on objects (Buffington, Krantz, McClannahan, & Poulson, 1998; J. M. Young, Krantz, Mcclannahan, & Poulson, 1994), gestures (Buffington et al., 1998), and oral-facial movements (DeQuinzio, Townsend, Sturmey, & Poulson, 2007). Several studies employing behavioral techniques that use peers as models also report positive results (Carr & Darcy, 1990; Ganz, Bourgeois, Flores, & Campos, 2008; Garfinkle & Schwartz, 2002). Video modeling, a behavioral technique that uses video-recorded stimuli rather than live scenarios to model behaviors, has been employed to teach imitation in ASD, with research providing mixed findings (D'Ateno, Mangiapanello, & Taylor, 2003; Rayner, 2011; Rayner, Denholm, & Sigafoos, 2009; Tereshko, MacDonald, & Ahearn, 2010).

In the past decade, developmental research has documented the importance of rewarding social interactions as a framework for learning (Kuhl, 2007). This has informed a new generation of play-based educational programs that places the emphasis on the social context of imitation, as well as the spontaneous use of imitation to learn and to socialize in untrained environments and in the absence of external reinforcement. The reciprocal imitation training model (Ingersoll & Gergans, 2007; Ingersoll, Lewis, & Kroman, 2007) is a naturalistic intervention based on dyadic play exchanges in which the therapist initially imitates the child behavior, thus establishing a turn-taking routine, and then models new actions for the child to imitate. If the child fails to imitate, the therapist prompts the imitative response. All spontaneous imitative behaviors are systematically reinforced through verbal praise. Results from a randomized control trial documented improvements in imitative skills in children undergoing this intervention, as well as gains in joint attention and social functioning (Ingersoll, 2010, 2011).

The Early Start Denver Model (ESDM; Rogers & Dawson, 2010) is a developmental, relationship-based program that employs teaching techniques to foster the development of skills that are foundational to social-cognitive development, including imitation, in young children with ASD. Imitative responses, rather than being taught in isolation, are targeted together with other social (e.g., joint attention, sharing of affect, verbal and nonverbal communication) and nonsocial skills (e.g., fine motor, nonverbal cognitive skills), in the framework of joint activity routines. In these routines the therapist creates a play activity that incorporates the child's choice and involves shared control of the materials and turn-taking exchanges. Instead of following a predetermined schedule, the adult models actions that are meaningful in the context of the play activity (e.g., gestures associated to a song routine, facial expressions to highlight the emotional context of the story in a book, or actions associated to a Play-Doh game), so to motivate the child to produce an imitative response in order to get the activity to continue. A randomized control trial of the ESDM has documented strong positive outcomes in cognitive and adaptive skills (Dawson et al., 2010), and a recent study found frequency of spontaneous imitation to be a positive predictor of outcomes in this intervention model (Vivanti et al., 2013).

The interpersonal synchrony model (Landa, Holman, O'Neill, & Stuart, 2011) focuses on fostering developmental gains in imitation, as well as in other social behaviors such as joint attention and affect sharing, within a group setting. The learning environment involves enhanced opportunities for motivating play-based interactions to promote the spontaneous occurrence of synchronous behavior, including contingent imitative responses to both adults and peers. A randomized control trial documented gains in the treatment group in imitation and other social initiations measures, which were maintained over a 6-month period (Landa et al., 2011). Overall, these studies suggest that including imitation in interventions for ASD is important, but more work is needed to link our theories of imitation to the teaching of imitation skills and to understand the role of imitation learning in driving improvements in social behavior in ASD.

CONCLUSIONS AND FUTURE DIRECTION

Understanding the nature of imitative difficulties in ASD is particularly challenging, as both imitative behavior and autistic behavior might result from a combination of different underlying factors, rather than being the expression of a single linear process or pathway. Different tasks draw on different cognitive processes, and these might be impaired to various degrees in some but not all the individuals in the spectrum. Advances in our understanding of the imitative deficit in ASD will be driven by the increasing recognition of the cognitive systems underlying imitation and of the particular ingredients that make specific imitation tasks difficult for particular individuals in the spectrum.

The findings presented in this chapter suggest that most individuals with ASD struggle more with imitation tasks involving actions that are unfamiliar and do not have a clear goal/outcome. Moreover, imitation performance appears to be poorer as the social-processing and/or motor demands in the task increase. Future research should take into consideration this pattern, rather than testing whether imitation is globally impaired in ASD, and systematically manipulate the different factors associated with the task (e.g., familiarity of the action, opacity of the demonstrator's goal, motor demand) to test the relevance of different candidate mechanisms. Furthermore, individual differences in imitation performance should be mapped into the different neuropsychological profiles of participants, to determine whether the levels of severity of different impairments (e.g., motor planning, goal understanding, or social attention difficulties) predict performance in tasks that pose a particular demand in specific areas.

A more fine-grained understanding of the different imitative behaviors is also needed to advance knowledge in the field. This approach involves a detailed analysis of both the demonstrator's and the imitator's behavior, with a particular attention to the means-end structure of the demonstrated action, the communicative signals conveyed by the demonstrator, the imitator's own goals, the nature of the instructions given, and the social, affective, and physical context in which the demonstration occurs. All these factors are known to affect imitation behavior, not only in terms of the accuracy of performance, but also in terms of the specific learning strategy used by the imitator (Horner & Whiten, 2005; Over & Carpenter, 2012); however, they are rarely taken into account in ASD research. Finally, as with many phenomena observed in ASD, it is crucial to distinguish between what individuals in the spectrum can do and what they actually do in their everyday life (Klin, Jones, Schultz, & Volkmar, 2003). This requires a new focus on carefully designed observational studies, looking at the factors that drive spontaneous imitative behaviors and the particular copying strategies used by individuals with ASD when they are and are not explicitly instructed to do so. Given that imitation is one of the most powerful tools for learning and socializing, advances in the field can make a significant difference in our ability to facilitate learning and support participation in cultural and social activities in the community for individuals with an ASD.

CROSS-REFERENCES

Chapter 5 focuses on autism in infants and young children. Social development is the focus of Chapter 9, and Chapter 11 focuses on play skills; interventions for young children are the focus in Chapter 29.

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Queries in Chapter 12

Q1. Reference Nielsen et al., 2012 has not been included in the Reference List, please supply full publication details.

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