Journal of Experimental Child Psychology 101 (2008) 165–169

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

Introduction

Reflecting on imitation in autism: Introduction to the special issue

In response to our call for papers for a special issue of *Journal of Experimental Child Psychology* on functions and mechanisms of imitation in childhood, we received a surprisingly large number of manuscripts on a wide range of topics. We were happy and encouraged that so much interesting work is being done on imitation, and sorry that space and time constraints meant that we could not publish more of them. We ended up with two special issues, one on imitation in children with autism (the current issue) and one on imitation in typically-developing children (forthcoming). Here we provide a brief introduction to the three papers that constitute the current issue on autism and offer some speculation on how these papers might shed light on one of the more keenly debated topics in recent developmental psychopathology research: the association between autism and a dysfunctional mirror system.

The identification of mirror neurons in the monkey prefrontal cortex (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Fogassi, & Gallese 1996) and subsequent mapping of the analogue mirror system in humans (Iacoboni et al., 1999) have been hyped as being among the most important psychological discoveries in the last two decades.[1] Indeed, it has been suggested that the mirror system may provide a unifying framework for understanding a host of human abilities including empathy, language, and theory of mind: Mirror neurons, it has been famously claimed, will do for psychology what DNA did for biology (Ramachandran, 2000). Of most relevance to the current issue, (1) the mirror system is considered to play a major role in the development and expression of imitation and (2) the symptoms associated with autism have been proposed to be directly attributable to mirror neuron dysfunction (see below). However, the papers in this issue provide information that calls some of these claims into question and that helps provide the foundation for a new perspective.

Originally discovered in macaque monkeys, mirror neurons were found to fire both when the monkey performed a specific action (e.g., reaching for a peanut) *and* when it observed someone else performing the same action. Such direct mapping of produced and seen actions has seemingly obvious implications for imitation. Indeed, a number of theorists have linked the mirror system to imitation, typically based on the assumption that imitation fundamentally relies on a mechanism that "directly maps a pictorial or kinematic description of the observed action onto an internal motor representation of the same action" (Iacoboni et al., 1999, p. 2526). There are problems with this so-called "direct matching hypothesis," though (Southgate, Gergely, & Csibra, in press; Southgate & Hamilton, 2008; Turella, Pierno, Tubaldi, & Castiello, in press). To begin with, monkeys, the only animal in which mirror neurons have been directly identified, are notoriously bad at imitation (Tomasello & Call, 1997). It has thus been suggested that mirror neurons are necessary but not sufficient for imitation to emerge:

[1] Note that because of the different methods used (single-cell recordings in monkeys versus noninvasive imaging techniques in humans) evidence for a human mirror system remains equivocal (see Dinstein, Thomas, Behrmann, & Heeger, 2008).

0022-0965/$ - see front matter
doi:10.1016/j.jecp.2008.06.004

What is also needed are concomitant increases in neocortical volume and in the complexity of the mirror system (Arbib, 2005; Hurley, 2008; Oberman & Ramachandran, 2007). Yet this perspective still underestimates the complexity of human imitative behavior, behavior that is evident from very early in childhood.

By age 12 months, typically-developing infants copy others' behavior selectively, based on a wide range of factors: the goals and intentions of the demonstrating adult (e.g., Bekkering, Wohlschläger, & Gattis, 2000; Carpenter, Akhtar, & Tomasello, 1998; Carpenter, Call, & Tomasello, 2002; Meltzoff, 1995), the model's communicative cues (Gergely, Egyed, & Király, 2007), the contingency of the model's behavior toward the child (Nielsen, Simcock, & Jenkins, in press), and the apparent rationality of the model's behavior (Gergely, Bekkering, & Király, 2002). It is thus clear that children's imitative ability is multifaceted and highly flexible. It is deployed in multiple contexts and for multiple purposes that are determined by a range of personal, interpersonal, and situational variables (Nielsen & Slaughter, 2007). Any theory that aims to reduce such behavior to a mechanism whose primary function is to match across felt and seen modalities cannot adequately account for this complexity.

As previously alluded to, the mirror system is thought to underpin a range of socio-cognitive processes—not just imitation. As many of these processes are affected in autism, it is no surprise that arguments directly linking a dysfunctional mirror system to the symptoms of autism are becoming increasingly prominent (Iacoboni & Dapratto, 2006; Oberman & Ramachandran, 2007; Williams, Whiten, Suddendorf, & Perrett, 2001). Related to the direct matching hypothesis, one perspective is that a dysfunctional mirror system results in impairments in drawing self-other motor correspondences (Williams et al., 2001). These impairments limit opportunities for imitation, leading to a cascade effect of other socio-cognitive deficits associated with autism. This position would be called into question if it were shown that the deficits in copying others shown by children with autism are not due to problems matching across felt and seen modalities. The first article in this special issue shows precisely that.

In this article, Hobson and Hobson follow up on R. P. Hobson's pioneering work on imitation of others' action "style" (e.g., Hobson & Lee, 1999) by investigating when and why copying style is difficult for children with autism. Hobson and Hobson showed children a series of goal-directed actions on objects. For some of them, they demonstrated the actions using a special action style, and within this subset of actions they also varied the relation of the style to the goal—whether it was intrinsic, necessary, or incidental to the goal. They found a pattern of results that is very difficult to explain with reference to mirror neurons: Whereas children without autism copied all types of actions at relatively high rates, children with autism copied the actions very selectively. These children reproduced the set of goal-directed actions without styles at rates equivalent to those of children without autism. However, they did not usually copy the style with which the other actions were brought about, and this was especially the case when the style was simply the way this particular person chose to perform the action, as opposed to when it was more intrinsically connected to the goal. Hobson and Hobson thus demonstrate that the impairment for children with autism does not lie in difficulties with action copying per se but instead with deeper social processes that, in their view, involve a more subjective identification with others.

The emphasis Hobson and Hobson's paper places on the social aspects of imitation is indicative of recent movements in developmental psychology. For most of its history, the study of children's copying behavior has focused almost exclusively on the instrumental or functional learning of novel actions on objects. There are good reasons for this, of course. Manipulating and exploiting objects as tools and artifacts is a defining characteristic of being human. Our children, more than the young of any other species, grow and develop in environments saturated with tools—tools that in one way or another they must learn to use if they are to become full-fledged members of their cultures (e.g., Gergely & Csibra, 2005; Tomasello, 1999). Considerable advances are still being made through recent research efforts to understand how children learn to use tools via imitation, as we will see with the second of these special issues on imitation. Nonetheless, a growing number of authors are concentrating their efforts on delineating the more interpersonal functions of imitation (e.g., Hobson, 2004; Nadel, Guérini, Pezé, & Rivet, 1999; Nielsen, 2006; Tomasello & Carpenter, 2007; Užgiris, 1981). This focus is significant, as understanding the social function of imitation is particularly helpful in explaining the pattern of relative strengths and weaknesses in imitation seen in children with autism, as attested to by Hobson and Hobson (see also Carpenter, 2006; Nadel, 2002; Nielsen, Suddendorf, & Dissanayake, 2006).

The relevance of focusing research attention on the social aspects of imitation is borne out by the second article in this special issue. Vivanti, Nadig, Ozonoff, and Rogers investigated the nature of the imitation deficit in autism by examining where children with autism and typically-developing children look when actions are being demonstrated to them. Using eye-tracking technology, they determined how long children spent looking to the face of the demonstrator versus looking to the area where the action was taking place. They did this with two different types of imitation tasks: imitation of meaningful actions on objects and imitation of nonmeaningful gestures, areas of relative strength and weakness, respectively, for children with autism (see Rogers, Cook, & Meryl, 2005; Williams, Whiten, & Singh, 2004). Their findings show that children with autism and typically-developing children look at to-be-imitated actions for similar durations, but typically-developing children look to the demonstrator's face twice as long as children with autism do. The typically-developing children may be looking to the demonstrator's face to check for information on what to do or how to respond appropriately (Carpenter & Call, 2007), information that the children with autism are less inclined to seek. Again, if imitation is just about mapping seen actions to motor output, why look to the demonstrator's face at all—unless you want to seek information about goals, intentions, and other "social" aspects of copying.

The final article investigated a different type of matching behavior. Following up on their previous work with adults, Beall, Moody, McIntosh, Hepburn, and Reed present a study of rapid facial reactions to emotional expressions in typically-developing children and children with autism spectrum disorder. Beall and colleagues showed children photographs of faces exhibiting different emotional expressions (happy, angry, and fearful) and measured the activation of corresponding muscles in children's faces using facial electromyography (EMG). Their aims were (1) to document whether children, like adults, exhibit rapid facial reactions and, if so, (2) to investigate the mechanism—motor mimicry versus emotional responses—underlying these reactions. They found that typically-developing children showed a pattern of responding that was very similar to that of adults: some matching and some complementary responses, indicating that at least some of these reactions can be explained by emotional responses to the stimuli. However, for children with autism spectrum disorder there was little evidence of consistent reactions. This work shows that children with autism do not respond to emotional facial expressions in the same way as their typically-developing peers. Although this result could be seen as consistent with the idea of a mirror system-based impairment in matching self–other correspondences, another possibility is that a dysfunctional mirror system causes a diminished capacity for processing social information, including facial expressions. It may be that it is to this role of the mirror system, as a basis for processing social information, that greater attention needs to be directed.

The human mirror system can provide a mechanism by which we share others' feelings and emotions, and it may be the neural space in which we connect with others (e.g., Gallese, 2005). It is in this way, to the extent that the mirror system works as the foundation for social binding, that a link with autism may be found. That is, the mirror system in individuals with autism may be dysfunctional—but dysfunctional in the way the system works to link us to each other and works to drive social motivations, not dysfunctional in the way it works to map seen to felt actions (see also Southgate & Hamilton, 2008). Continued research efforts at charting the neural basis of autism may thus find most fruitful ground in identifying how the mirror system works to process social information, and specifically to process those forms of imitation that are socially laden.

Autism remains one of the most intriguing and enigmatic psychopathologies. It has drawn, and continues to draw, widespread interest. This is in no small part because the constellation of deficits characterizing this disorder are seemingly quintessential human traits: language, theory of mind, joint attention, imaginary play – and imitation. The three papers that make up this special issue shed new light on imitation in autism and provide direction for future research. Autism is a complex disorder and finding its causes, including its neural ones, is a challenging endeavor. The work presented in this special issue will help us look in the right places.

Acknowledgments

We thank David Bjorklund for inviting us to edit these special issues and for his guidance and patience in helping us to get them together. We also thank all the reviewers who took the time to

provide such helpful comments on the submissions. Finally, we thank Jason Mattingley for providing valuable feedback on a draft of this introduction.

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