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A developmental perspective on action and social cognition

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Abstract

The target article argues that developmental processes are key to understanding the mirror neuron system, yet neglects several bodies of development research that are informative for doing so. Infants' actions and action understanding are structured by goals, and the former lends structure to the latter. Evaluating the origins and functions of mirror neurons depends on integrating investigations of neural, social-cognitive and motor development.

Cook et al. articulate two conclusions with which we wholeheartedly agree: (1) The functions of mirror neurons (MNs) cannot be determined based only on patterns of neural activation during action observation. Independent measures of the putative social-cognitive functions of MNs are needed and have, so far, not been sufficiently integrated with neural measures; and (2) understanding the developmental origins of MNs and the broader systems in which they are situated is essential for understanding their functional significance.

Given the centrality of developmental processes to Cook et al.'s arguments, we find it surprising that they do not engage the developmental literature more fully. They propose a relatively simple learning process—the formation of contingency-based associations between visual and motor experience—to account for the existence of MNs. For example, they propose that MNs reflect repeated experiences with reaching for objects and seeing the resulting hand movements. This kind of learning seems very likely to occur but without a fuller consideration of motor and social-cognitive development, it is difficult to see how any important social-cognitive functions could arise from motor experience. In fact, several bodies of experimental work with human infants indicate that much richer connections exist between motor experience and social cognition.

Developmental research shows that infants' actions are prospectively goal-directed from very early in infancy (von Hofsten 1980; 2004), and during the first year, manual skills become increasingly well-organized (Thelen et al. 1996; von Hofsten & Ronnqvist 1988). For example, Claxton et al. (2003) demonstrated that infants reach for objects differently depending on what they intend to do next: They are faster to reach for a ball if they are going to throw it versus place it into a container. Further, over the course of the first year of life, infants begin to systematically anticipate the shape, size, and orientation of the objects that they grasp (von Hofsten & Ronnqvist 1988). This body of work shows that motor competence even in young infants involves abstract action plans, as it does in adults (Rosenbaum 1991). This fact about infants' actions has implications for the role that action experience might play in infants' perception of others' actions as organized by goals.

In fact, converging research has shown that infants also view others' actions as structured by goals. Infants encode others' actions in terms of the relation between agent and goal (e.g., Brandone & Wellman 2009; Luo & Johnson 2009; Sodian & Thoermer 2004; Sommerville & Woodward 2005; Woodward 1998), selectively imitate the goals of others' actions (Gerson & Woodward 2012; Hamlin et al. 2008; Meltzoff 1995), and anticipate the outcomes of others' actions based on their goals (Cannon & Woodward 2012; Gredebäck et al. 2009; Kanakogi & Itakura 2010; Krogh-Jespersen & Woodward, under review). Moreover, across these findings, matched comparison conditions and fine-grained analyses of infants' attention during the tasks have shown that infants' responses reflect more than simply attention to physical movements or low-level associations between hands and objects. Instead, this body of evidence shows that infants analyze others' behavior in terms of the abstract relational structure that organizes goal-directed actions.

Importantly, infants' action understanding is related to and shaped by their action experience. The emergence of goal-directed actions in infants' own motor repertoires correlates with their analysis of these actions in others (e.g., Brune & Woodward 2007; Cannon et al. 2012; Kanakogi & Itakura 2011; Loucks & Sommerville 2012; Sommerville & Woodward 2005). Critically, interventions that change infants' own actions render changes in their analysis of others' action goals. For example, 3-month-old infants are not yet efficient at reaching, but, given training to use Velero “sticky” mittens to apprehend objects, they subsequently demonstrate an understanding of others' reaches as goal-directed (Sommerville et al. 2005). Matched training that involves passively observing others' reaches does not have this effect (Gerson & Woodward 2014; for related findings, see Libertus & Needham 2010; Sommerville et al. 2008). Thus, this body of work shows that infants' own experience producing goal-directed actions informs their understanding of the goals that structure others' actions.

Nevertheless, studies of infants have made only preliminary progress in the domain in which the MN hypothesis originated—neural processes. We agree with Cook and colleagues that a systems approach is needed to evaluate the functional relations that may be signaled by the firing properties of MNs. In human infant research, we have neither the precision of single-cell recordings nor (yet) an analysis of connectivity among potential components of the mirror neuron system (MNS). Even so, infants' evidence neural activity in the motor system during observation of others' actions (Marshall et al. 2011; Nyström et al. 2011; Southgate et al. 2009). Critically, changes in infants' motor experience modulate this neural response to others' actions. Developments in infants' motor skill affect the motor system's response to others' actions (Cannon et al., under review; van Elk et al. 2008), and short-term manipulations of motor experience in infants generate similar effects (Marshall et al. 2013; Paulus et al. 2012). Yet, as Cook et al. point out with regard to the adult work, the critical connection between the MNS and social understanding has not been made for infants. Establishing this connection requires integrating neural techniques with behavioral methods for investigating social cognition in infants.

Cook et al. use a developmental framework to argue against over-interpretation of MN findings. While we see merit in their argument that many open questions still exist concerning the MNS, we also advise against throwing out the baby with the bathwater.

Rather than using developmental arguments to minimize the potential significance of MNs for social cognition, the field should be pushing forward to understand the links between neural systems, social cognition, and motor skill. Because each of these systems undergoes rapid and dramatic change during early ontogeny, a developmental approach is likely to shed the most light on the links between them.

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