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Beyond rational imitation: Learning arbitrary means actions from communicative demonstrations

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ABSTRACT

The principle of rationality has been invoked to explain that infants expect agents to perform the most efficient means action to attain a goal. It has also been demonstrated that infants take into account the efficiency of observed actions to achieve a goal outcome when deciding whether to reenact a specific behavior or not. It is puzzling, however, that they also tend to imitate an apparently suboptimal unfamiliar action even when they can bring about the same outcome more efficiently by applying a more rational action alternative available to them. We propose that this apparently paradoxical behavior is explained by infants' interpretation of action demonstrations as communicative manifestations of novel and culturally relevant means actions to be acquired, and we present empirical evidence supporting this proposal. In Experiment 1, we found that 14-month-olds reenacted novel arbitrary means actions only following a communicative demonstration. Experiment 2 showed that infants' inclination to reproduce communicatively manifested novel actions is restricted to behaviors they can construe as goal-directed instrumental acts. The study also provides evidence that infants' reenactment of the demonstrated novel actions reflects epistemic motives rather than purely social motives. We argue that ostensive communication enables infants to represent the teleological structure of novel actions even when the causal relations between means and end are cognitively opaque and apparently violate the efficiency expectation derived from the principle of rationality. This new account of imitative learning of novel means shows how the teleological stance and natural pedagogy—two separate cognitive adaptations to interpret

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instrumental versus communicative actions—are integrated as a system for learning socially constituted instrumental knowledge in humans.

Introduction

The principle of rationality as a fundamental factor governing action selection in knowledge-based systems was introduced by Newell (1982): "If an agent has knowledge that one of its actions will lead to one of its goals, then the agent will select that action" (p. 102). The rationality principle has also been proposed to be the central inferential principle in Gergely and Csibra's (2003) theory of human infants' teleological action interpretation mechanism. This core system is a cognitive adaptation to represent instrumental actions in terms of their teleo-functional properties. It implements human infants' naive theory of rational action in the domain of instrumental agency by representing actions as efficient means to bring about specific goal states in the world. The main tenets of the rationality principle are that (a) actions serve to bring about future goal states and (b) goal states are realized by the most efficient action available to the actor within the constraints of the situation (Gergely & Csibra, 2003). Teleological reasoning (just like mentalistic or practical reasoning about actions) relates three aspects of action interpretation—goals, actions, and situational constraints—in a systematic manner by the "rationality assumption": Given information about any two of the three elements, one can infer (and predict) what the third element ought to be (Csibra, Bíró, Koós, & Gergely, 2003).

Using violation of expectation and eye-tracking paradigms, ample evidence confirms that infants can make inferences about observed actions with the help of teleological reasoning (Gergely, Nadasdy, Csibra, & Bíró, 1995; see also Biro, Csibra, & Gergely, 2007; Biro, Verschoor, & Coenen, 2011; Csibra, 2007; Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Csibra et al., 2003; Gredebäck & Melinder, 2010; Gredebäck & Melinder, 2011; Hernik & Southgate, 2012; Kamewari, Kato, Kanda, Ishiguro, & Hiraki, 2005; Sodian, Schoeppner, & Metz, 2004; Southgate & Csibra, 2009; Verschoor & Biro, 2012; Wagner & Carey, 2005; Woodward & Sommerville, 2000).

If infants expect other agents to act rationally by choosing to perform the most efficient means available to the goal, one would expect infants themselves to rely on the same principle of rationality to guide their own choices of instrumental actions as well. This prediction, however, was apparently contradicted by the results of Meltzoff's (1988) seminal imitation study, in which infants chose to reenact a model's unusual and subefficient head action to illuminate a light box instead of just using their hands to induce the same effect. Optimizing to "least effort," operating the light box by touching it with one's hand seems more efficient (and hence more rational) than bending forward from the waist to use one's forehead to achieve the same end. To address this puzzle, Gergely, Bekkering, and Király (2002) developed a modified version of Meltzoff's (1988) imitation paradigm to test whether efficiency evaluations could modify infants' action choice and production by introducing a new context condition in which the demonstrator's hands were occupied when she performed the unfamiliar head action to operate the touch lamp (*hands-occupied* condition). Whereas in the original *hands-free* condition 69% of infants reenacted the head action (replicating Meltzoff's results), the number of "imitators" dropped significantly to only 21% in the hands-occupied condition. Gergely and colleagues (2002) referred to this phenomenon of context-sensitive learning of novel means actions as "rational imitation." Since the original demonstration, the finding of selective rational imitation has been replicated several times and shown to generalize across a range of different task contexts with 12- and 14-month-olds (Buttelmann, Carpenter, Call, & Tomasello, 2008; Király, 2009a; Schwier, van Maanen, Carpenter, & Tomasello, 2006; Zmyj, Daum, & Aschersleben, 2009).

The explanation of context-sensitive and selective reenactment of novel actions in terms of rational imitation, however, has been challenged on several grounds. One alternative account developed by Paulus, Hunnius, Vissers, and Bekkering (2011a, 2011b) suggests that the phenomenon is attributable to the interaction between automatic motor resonance elicited by the observed actions and the limited motor capabilities of infants. Another contrasting view was proposed by Beisert, Zmyj, Liepelt,