Infant Behavior & Development 37 (2014) 21–28

Contents lists available at ScienceDirect

Infant Behavior and Development

An integrative model of rational imitation in infancy

Norbert Zmyj [a,*], David Buttelmann [b]

[a] Ruhr-Universität Bochum, Bochum, Germany
[b] Research Group, Kleinkindforschung in Thüringen, University of Erfurt, Germany

ARTICLE INFO

Article history:
Received 3 January 2013
Received in revised form 4 September 2013
Accepted 31 October 2013
Available online 14 December 2013

Keywords:
Imitation
Rational imitation
Motor resonance
Action effects
Infants

ABSTRACT

It has been proposed that infants selectively imitate based on a rational evaluation of an observed action (Gergely, Bekkering, & Király, 2002). This rational-imitation account has been rejected based on findings which suggested that infant imitation depends on: (a) the similarity between the infant's and the model's body posture; and (b) the presence of action effects (Paulus, Hunnius, Vissers, & Bekkering, 2011). Despite this controversy, we show that both accounts have received empirical support from different fields of research. We propose that both accounts operate on different levels, and we present an integrative model, which combines the two seemingly competing accounts. Motor resonance is perceived as a mechanism that enables infants to imitate, and a rational evaluation of the model's action is conceived as a mechanism that guides infants' imitative behavior.

1. Introduction

Imitation, defined as copying the behavior that another individual has demonstrated (Barr, Dowden, & Hayne, 1996; Paulus, 2011; Ray & Heyes, 2011), is one of the most prominent methods used in developmental psychology to investigate infants' social-cognitive abilities. There is a lively debate concerning the appropriate interpretation of studies, which use imitation paradigms. Proponents of the concept that infants' imitation is based on a sophisticated understanding of the environment or a model's mental states have proposed a variety of possible influences on infants' imitative behavior. They claim that imitation is guided by reasoning about intentionality (Carpenter, Akhtar, & Tomasello, 1998), necessity (Brugger, Lariviere, Mumme, & Bushnell, 2007), and rationality (Gergely, Bekkering, & Király, 2002). Recently, the idea that infants imitate in accordance with the principle of rational action (Gergely et al., 2002) has been fundamentally criticized (Paulus, Hunnius, & Bekkering, 2013a; Paulus, Hunnius, Vissers, & Bekkering, 2011a, 2011b).

The controversy begins with the very definition of imitation (Byrne & Russon, 1998; Meltzoff, 1988; Whiten, Horner, Litchfield, & Marshall-Pescini, 2004). Some define imitation as behavior that is similar to an observed behavior without focusing on its rational basis (Brass, Bekkering, Wohlschlager, & Prinz, 2000; Hauf, Elsner, & Aschersleben, 2004; James, 1890/1950; Prinz, 1997; Ray & Heyes, 2011). A key problem discussed in this line of research is how individuals encompass the so-called 'correspondence problem': The transformation of sensory codes into motor codes. In contrast, others define imitation as a deliberate copying of the intended end-state of an observed action by using the same means as the model (Carpenter & Call, 2009; Tomasello, Kruger, & Ratner, 1993; Whiten, McGuigan, Marshall-Pescini, & Hopper, 2009). Hence, the key problem here is differentiating imitation from other processes that produce overtly similar results. First, performing the same body movements (i.e., mimicry) could accidently result in the observed end-state, even though achieving the end-state was not intended. Second, copying the end-state (i.e., emulation) could be achieved by using one's own means that are unintentionally identical with the observed means.

* Corresponding author. Tel.: +49 234 3227783.
E-mail address: norbert.zmyj@rub.de (N. Zmyj).

0163-6383/$ – see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.infbeh.2013.10.001

Since we compare two accounts that use different definitions of imitation, we broadly define imitation as any executed behavior that matches the demonstrated one (following Paulus, 2011).

1.1. The basis of the rational-imitation account: the principle of rational action and natural pedagogy

The rational-imitation account builds on the idea that infants evaluate three components of another person's behavior: the observable goal (in terms of end-state), the means that are used to achieve this goal, and the situational constraints in which this means-end relation is embedded (Gergely & Csibra, 2003). It is further assumed that infants apply the principle of rational action (Gergely & Csibra, 2003) to make sense of the observed behavior. This account makes two assumptions (Gergely & Jacob, 2012). First, infants interpret other agents' instrumental actions as goal-directed. Second, infants identify the most efficient means by which to achieve the goal among all possible options that accord with the situational constraints, and, hence, assume that other agents also use the most efficient means available to them to obtain their goal. If infants perceive an action, they only imitate the applied means to achieve the observed goal if it appears to be the most efficient action available given the situational constraints.

The rational-imitation account has recently been specified in terms of the role of natural pedagogy (Gergely & Jacob, 2012; Király, Csibra, & Gergely, 2013). The aforementioned evaluation only operates if the model establishes a pedagogical context by displaying ostensive cues such as eye-contact or calling the infant's name. By doing so, the model signals that new and relevant knowledge is going to be presented even if the modeled means-end relation does not seem to be the most efficient one. Thus, infants consider this demonstration is worthy of imitation, and imitate the novel action. In contrast, if the model does not display ostensive cues to the infant (e.g., in third party interactions), inefficient means-end relations are not perceived as containing new and relevant knowledge and are consequently not imitated.

1.1.1. Empirical evidence for the influence of the principle of rational action and natural pedagogy on infants' imitative behavior

There is evidence from looking time studies, which show that infants are sensitive to the basic elements of the rational-imitation account described above. First, infants as young as 6 months of age interpret an agent's behavior as goal-directed. In the seminal study by Woodward (1998), infants were habituated to the event of a hand grasping one of two toys. Then, the positions of the objects were switched and the hand grasped either the new toy at the old location or the old toy at the new location. Infants looked longer when the arm grasped the new toy at the old location, which indicates that infants interpret others' behavior as goal-directed. Further, follow-up studies revealed that infants interpret movements as goal-directed even if the action is not in the infants' motor repertoire: For example, if the objects are not grasped but instead touched with the back of the hand (Jovanovic et al., 2007; Király, Jovanovic, Prinz, Aschersleben, & Gergely, 2003): Infants looked longer when the back of the hand touched the new object at the old location compared to when the back of the hand touched the old object at the new location. Similarly, infants show the same pattern of results when the human hand is replaced by a rigid rod that approached the goal object from different angles (Bíró & Leslie, 2007), when the human hand is replaced by a rectangular box (Luo & Baillargeon, 2005), or when a video shows a computer animated human hand performing anatomically impossible movements (Southgate, Johnson, & Csibra, 2008).

Second, a number of studies have reported that infants apply the principle of rational action to agents (Bíró, 2012; Csibra, 2008; Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Gergely, Nádasdy, Csibra, & Bíró, 1995; Sodian, Schoeppner, & Metz, 2004). The logic of these studies rests on the following series of events that was introduced by Gergely et al. (1995). First, infants were habituated to a small circular object that jumped over a rectangular obstacle and approached a large circular object. Then, in the test trial, the obstacle was absent and the small object approached the large object following either the old path or a new straightforward one. Infants looked longer at the old-path display than at the new-path display. This pattern of results is interpreted as evidence for infants being surprised when the agent used an inefficient – yet familiar – means to achieve a goal.

Third, there is also evidence for the influence of natural pedagogy on infants' behavior. Ostensive cues, such as establishing eye-contact or raising eyebrows, have been shown to affect infants' imitation. For example, infants are more likely to imitate those aspects of an action that were marked with ostensive cues compared to aspects that were not (Southgate et al., 2008).

1.2. The basis of the two-stage model of infant imitation: motor resonance and action effects

Recently, Paulus et al. (2011a, 2011b) introduced the two-stage model of infants' ability to imitate observed action-effect contingencies (hereafter labeled as the two-stage model) as a new approach to interpret selective imitation in infancy. They assumed that two stages guide imitation. First, infants have to overcome the correspondence problem between the observation of another person's action and the subsequent execution of this action. Infants are able to link these processes because action observation and action execution are automatically connected (motor resonance). Second, infants' imitative behavior is guided by action effects. This second step is based on the framework of the common coding theory (Hommel, Musseler, Aschersleben, & Prinz, 2001; Prinz, 1997). Here, it is assumed that an action and an action effect are associated bi-directionally. If infants perceive an action effect, then the action effect automatically activates a motor program that would result in the perceived action effect.