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Early rationality in action perception and production? A theoretical exposition

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ABSTRACT

Within recent years, the question of early rationality in action perception and production has become a topic of great interest in developmental psychology. On the one hand, studies have provided evidence for rational action perception and action imitation even in very young infants. On the other hand, scholars have recently questioned these interpretations and proposed that the ability to rationally evaluate actions is not yet in place in infancy. Others have examined the development of the ability to make rational action choices and have indicated limitations of young children's ability to act rationally. This editorial to the special issue on *Early Rationality in Action Perception and Production?* introduces the reader to the current debate. It elucidates the underlying theoretical assumptions that drive the debate on whether or not young children's action perception and production is rational. Finally, it summarizes the papers and their contributions to the theoretical debate.

Introduction

Learning how to act and learning how to make sense of others' actions are undeniably two of the most important tasks young children need to master during early development. How are children able to do so? Is their learning about actions supported by sophisticated reasoning about the rationality of each of the possible actions (and thus in itself rational), or is it subserved by rather low-level mechanisms?

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It is well established that newborns are rather helpless beings, missing central abilities to control much of their own behavior. Some studies have suggested that it is not before 5 months of life that they learn to guide their grasping behavior through visual information (von Hofsten, 1980, 1983). More efficient anticipatory action planning abilities seem to develop only during the course of the second year of life (e.g., McCarty, Clifton, & Collard, 1999, 2001). Moreover, researchers have pointed to limitations in young children's ability to make rational, goal-directed action choices (Kenward, Folke, Holmberg, Johansson, & Gredebäck, 2009; Klossek & Dickinson, 2012). Yet, it has also been reported that 1-year-old infants can adjust their initial grasp of an object in relation to their overall goal in the situation (Claxton, Keen, & McCarty, 2003), suggestive of a basic ability to act in a goal-directed fashion already during the first year of life (von Hofsten, 2004).

Concerning action perception, it has been argued that from an early age, children differentiate between animate and inanimate beings (e.g., Jeschonek, Marinovic, Hoehl, Elsner, & Pauen, 2010; Pauen, 2002; Quinn & Eimas, 1998). This categorical distinction is supported by a body of research suggesting that infants interpret the movements of inanimate objects in terms of physical laws, whereas they interpret people and other animate entities in terms of goals and intentions (e.g., Woodward, 1998). This differentiation is at the root of what has been labeled as naive psychology (Poulin-Dubois, Brooker, & Chow, 2009), which ultimately leads to an understanding of others as mental beings (Aschersleben, Hofer, & Jovanovic, 2008; Barresi & Moore, 1996; Perner, 1991; Thoermer, Sodian, Vuori, Perst, & Kristen, 2012).

Action perception and action production are part of social learning and, in particular, of imitation during early childhood. Imitation is highly relevant for social and cognitive development (e.g., Over & Carpenter, 2012; Tomasello, Carpenter, Call, Behne, & Moll, 2005). In imitation, action perception and action production are intertwined because children rely on perceived information about others' behavior to control their own future actions. Thus, studying imitation offers insights into both how young children perceive others' behavior and how they plan their own actions (e.g., Elsner, 2007).

Taken together, this short overview demonstrates that a closer examination of the development and nature of early action production and perception is of central relevance for developmental psychology.

Disagreement on neurocognitive mechanisms

Notwithstanding the general agreement on the relevance of studying the early roots and early development of action perception and production, there is great disagreement in the field when it comes to the underlying neurocognitive mechanisms. The proposed mechanisms are greatly divergent, ranging from low-level sensorimotor mechanisms (cf. Smith & Sheya, 2010; Thelen & Smith, 1994) to relatively high-level cognitive and conceptual ways of processing others' actions (e.g., Gergely & Csibra, 2003). Where does this disagreement come from? What are the underlying theoretical assumptions that drive this debate? It appears that the discussions of the respective lean and rich accounts of young children's action perception and production have evolved around a number of issues.

Phylogenetic and ontogenetic considerations

One line of reasoning suggests that children are confronted with a considerable amount of information. Undeniably, young children observe a lot of different actions and are presented with a lot of objects to act on. For example, they spend a great deal of time observing their caregivers walking around in a room, reaching for and grasping objects as well as performing actions with them, the purpose of which must be largely opaque for the children.

A central argument in this line of reasoning suggests that children must be overwhelmed with all this information. It must be difficult for them to figure out which aspect of an action to focus on. In other words, how can children deal with the vast amount of information? This issue is particularly relevant with respect to cultural learning. It is clear that the success of *Homo sapiens* rests on the cultural transmission of knowledge from one generation to another (e.g., Gould, 1979). Yet, the question that arises is, how is this possible? How do young children regulate which kind of behaviors they imitate?

Some theories assume that inborn principles must guide this learning process because otherwise children would be stunned with information. In other words, it has been proposed that there need to be biological adaptations for cultural learning. These evolutionary inherited mechanisms enable developing organisms to identify the relevant and crucial information (e.g., Csibra, 2010) that would otherwise remain opaque for the learning system. As an example, the model of natural pedagogy (Csibra & Gergely, 2009) maintains that ostensive communication induces an expectation of *genericity*, which leads even young children to assume that the demonstrated behavior is generic knowledge that is shared across situations and across individuals. The same inferential processes that might underlie adult communication—that is, maximizing the relevance of the information shared (cf. Sperber & Wilson, 1986)—already seem to underlie infants' interactions with others, for example, when they selectively imitate others' behavior (e.g., Király, 2009; Southgate, Chevallier, & Csibra, 2009).

This assumption of an inferential learning process seems to be supported by research suggesting that even infants are able to reason about others' behavior in a quite complex way. It has been suggested that they evaluate the efficiency of means in others' goal-directed actions (e.g., Csibra, Gergely, Bíró, Koós, & Brockbank, 1999; Verschoor & Biro, 2012) and selectively imitate aspects of a behavior that seem to be relevant (rational imitation; e.g., Gergely, Bekkering, & Király, 2002; Zmyj, Daum, & Aschersleben, 2009). Furthermore, it has been argued that already infants treat communicative cues on more than just a purely perceptual level; they interpret them as signals that initiate referential communication (Senju & Csibra, 2008).

In contrast, other approaches stress processes of self-organization and the impact of the multimodality of sensorimotor learning experiences (e.g., Smith & Gasser, 2005). In particular, learning through mere observation and trial and error might do part of the job, particularly when taking the long developmental phases into account (Hommel, Müsseler, Aschersleben, & Prinz, 2001; Paulus, Hunnius, Vissers, & Bekkering, 2011). That is, the earliest forms of cultural learning could be based on sensorimotor learning (Paulus, Hunnius, & Bekkering, in press). Higher order cognitive processes subserving cultural learning at a later point in time could themselves be the product of cultural learning (Heyes, 2012). One theoretical approach suggests that imitative learning is mediated by the observers' motor abilities insofar as observed actions elicit automatic motor activation (motor resonance; Paulus et al., 2011).

Finally, others have assumed that much of the learning process could be guided by the social environment that selects the relevant information and presents it to developing children in a facilitated manner (e.g., Rogoff, 2003). For example, in language development, it has been shown that caregivers tend to overstress particular sounds to support their infants' learning about the relevant parts of language (''motherese''; Fernald, 1985). A similar phenomenon has been reported in action demonstrations. Brand and colleagues have provided evidence for a behavioral tendency called ''motionese'' (e.g., Brand, Baldwin, & Ashburn, 2002; Brand & Shallcross, 2008). Here, it was found that caregivers modify their actions when they present them to their infants. In particular, they tend to repeat important parts of actions, adapt the motor characteristics, and simplify the actions. Others have analyzed how caregivers and social interaction partners point young children to mental states as explanations for social behavior, thereby facilitating the acquisition of a theory of mind (Carpendale & Lewis, 2004).

These theoretical approaches lead to a differential ascription of cognitive competencies to young children. In addition, they stress rationality in different manners. If we take the first approach, aspects of rationality seem to be embedded in children's own cognitive systems as they need to analyze and weigh the aspects of others' behavior (i.e., it is the cognitive system that needs to make rational considerations). Yet, if we were, for example, to assume that learning processes are mostly socially guided, ''rational'' aspects seem to be largely embedded in the social environment and do not need to be placed in single organisms.

Definitions of key concepts

Another line of inquiry that heats up the debate concerns how to differentiate high-level cognitive from noncognitive (i.e., sensorimotor) mechanisms. Classically, Piaget (1952) pleaded for a developmental differentiation between sensorimotor and cognitive processes. According to his genetic epistemology, infants' behavior and competencies are based on sensorimotor processes that are rooted in action and perception. Complex reasoning processes only develop later. Likewise, it has been argued

that the very early forms of social understanding are based on sensorimotor processes (Barresi & Moore, 1996). Accordingly, taking an action perspective, it has been suggested that researchers should be looking at how young children learn to react adequately to something rather than asking how they conceive of something (e.g., Bibok, Carpendale, & Lewis, 2008).

On the contrary, Spelke (1988, 1998), for example, argued that cognitive and conceptual abilities must be there from birth because even newborns seem to comprehend the outer world as consisting of independent entities. Accordingly, one could argue that every kind of perception includes cognitive and conceptual processes. Such considerations relate to work, suggesting that even infants conceive of others as mental agents (Luo & Baillargeon, 2010; for a review, see Sodian, 2011).

There is, however, a difficulty that constrains this debate. As long as there is no clear differentiation between sensorimotor processes and cognitive processes, a debate on which of these mechanisms underlie action perception and production will probably remain fruitless.

A related problem arises for the meaning of rationality. In current discourse, it remains partly an open question when to characterize a behavior as being rational. This is because the concept of rationality can be used in a number of different ways (e.g., Habermas, 1985, 1990; Hacker, 2010; Sturm, 2012). For example, rationality could designate a behavior when it is the correctly chosen means to achieve a given goal. Here, rationality is used in the sense of instrumental rationality. This kind of rationality is closely related to simple action planning mechanisms, which seem to develop during the second year of life (e.g., McCarty et al., 1999, 2001). Yet, this is a very simple sense of rationality.

Other forms of rationality refer to its communicative nature (Habermas, 1985), encompassing the giving and accepting of reasons in a discourse with other agents. Here, language seems to be the key factor underlying this form of rationality. One reason is that language is the only way to express propositional content and to give reason (Brandom, 1994). Moreover, from a methodological point of view, Davidson (1982) pointed out that it is only through language that we have a concept of objective truth, which is a precondition for having propositional attitudes that can be judged to be rational or not.

Finally, from a systems and evolutionary point of view, one could argue that rational behavior does not need to be based on the decision of an individual but instead could be inherent in, for example, the processes of a social system (e.g., Giddens, 2009; for an early formulation, see Smith, 1981). That is, although the individual might be unaware of the rationality or purposefulness of the behavior, it can be construed as being rational in a particular sense from a theoretical point of view (e.g., when serving the stability of a social system). Yet, here it is the onlooker who judges the rationality of a particular behavior and not the agent itself.

In conclusion, an answer to the question of how rational infants' action perception and production is depends on how the concept of rationality is used and which aspect of rationality is stressed in the respective theory.

Theoretical problems

Another line of reasoning comes from theoretical and epistemological analyses of infant behavior.

On the one hand, theoretical work has tried to examine the cognitive preconditions that must be fulfilled to be able to engage in conceptual/cognitive processing of others' actions—and whether or not these cognitive abilities are likely to be in place early in development (e.g., Müller & Giesbrecht, 2008). Relying on such conceptual analyses, a number of authors have suggested that some current interpretations of infants' behaviors are too rich because they need to make assumptions on other competencies in young infants for which we have no evidence (e.g., Haith, 1998; Paulus, 2012; Tissaw, 2007; Welsh, 2006).

Furthermore, advocates of sensorimotor approaches have proposed that knowledge is bodily grounded in sensorimotor experiences (Barsalou, 2008; Fischer & Zwaan, 2008). In particular, it has been argued that abstract representations need to be grounded in and based on nonsymbolic representations because a net of abstract propositions could otherwise not be related to the physical world (cf. Harnad, 1990).

On the other hand, critics of pure sensorimotor approaches have pointed to the problem that it remains unclear how complex reasoning skills can develop out of mere perceptual primitives and how conceptual thinking can emerge out of basic, reflexive sensorimotor processes. In other words, it has

been argued that sensorimotor approaches never provided adequate definitions for concepts (Fodor, 1983). They could not propose a learning mechanism that can account for the creation of nonperceptual representations given the beginning stage containing only them (Carey, 2009) and cannot explain the rapid buildup of general knowledge (Leslie, 1986).

As a consequence, from a theoretical point of view, proponents of rich accounts have argued that the foundation of action perception and action execution in sensorimotor accounts faces the problem of the emergence of conceptual representations and general knowledge that must go beyond the appearances to underlying realities (Leslie, 1986). Thus, from this theoretical angle, the enhancement of development presupposes bootstrapping processes that need to be in place already very early in development (Carey, 2009).

Taken together, one issue in the debate on how to think about early competencies seems to be to further clarify the assumptions one needs to make when (not) attributing particular skills.

Contributions in the current issue

This special issue of the *Journal of Experimental Child Psychology* contains a number of contributions that explore the question of early rationality in greater detail. The contributions take a variety of different perspectives on this matter and employ different methods.

Using eye-tracking techniques, three articles examine infants' perception of others' actions in greater detail.

Biro investigated the conditions under which infants might rely on teleological inferences to evaluate the efficiency of others' actions. The study suggests that 13-month-old infants expect abstract figures to behave in the most efficient manner even when movement extrapolation is prevented and when the goal is not salient.

Elsner, Pfeifer, Parker, and Hauf presented 13- to 15-month-old infants with a number of imitation tasks that have widely been employed to demonstrate rational imitation in preverbal infants. Examining how children perceive the tasks and characteristics, the authors provide evidence that the infants process the important information in the action demonstration. They argue that their results provide evidence for an interaction between low-level perceptual processes and high-level cognitive processes in infants' action perception.

De Bordes, Cox, Hasselman, and Cillessen took a closer look at the mechanisms underlying 20-month-old children's perception of others' gaze in pedagogical demonstrations. Manipulating the presence of ostensive cues and the saliency of the eyes, they suggest that toddlers' gaze following is driven by general attention mechanisms rather than by their appreciation of somebody else's communicative intent.

Using electroencephalography, Pace, Carver, and Friend investigated 24-month-old children's and adults' neurophysiological responses to intact and disrupted actions. They argue that two distinct mechanisms, a perceptual one and a conceptual one, contribute to children's and adults' action processing.

The following contributions focus on imitation, bridging the gap between action perception and execution.

Király, Csibra, and Gergely examined 14-month-old infants' imitation of an unusual and novel action while manipulating the communicative context of the action demonstration. Their results suggest that the imitation of a novel and cognitively opaque behavior can be explained by infants' interpretation of actions as manifestations of novel and culturally relevant means actions to be acquired.

Paulus, Hunnius, and Bekkering investigated whether 14-month-old children's imitation of novel actions is based on sensorimotor processes or whether inferential processes such as teleological reasoning predominantly explain selective imitation during infancy. The findings indicate that infants' imitative learning is not affected by actions' apparent efficiency but that sensorimotor processes play a fundamental role in early imitation.

Thoermer, Woodward, Sodian, Perst, and Kristen examined whether 7-month-old infants' perception of others' actions and their imitation of a novel action are related. The results show intertask

convergence independent of working memory, supporting the view that infants understand others' goals on a conceptual level.

Yang, Bushnell, Buchanan, and Sobel focused on how 15-month-old infants learn from the demonstration of effective and ineffective actions and how they use this information in their subsequent imitation. The results show that infants are able to generalize efficacy information to a novel object. Their model explains this performance through assuming several pedagogical assumptions in the information processing mechanisms.

Extending the question of early rationality to slightly older children, the final two contributions examine rational action production and imitation in preschoolers.

Pfeifer and Elsner took a number of tasks, which have been used to assess rationality in infants, and presented them to 3- to 5-year-old preschoolers in an imitation paradigm. Their results show differences in children's imitation across the tasks. The findings suggest that preschoolers adjust their imitative behavior to context-specific information about objects and actions.

Priewasser, Roessler, and Perner examined preschoolers' performances in a competitive game, supposing that understanding rational actions requires perspective taking with respect to both the *mean actions used* by and the *objectives* of the opponent. The results of the study speak for an interrelated development of the two kinds of perspective taking (instrumental and telic), subserving the development of rational action understanding and planning.

Overall, the current contributions widen our knowledge with respect to young children's developing capabilities of action processing and production while illustrating the different approaches in handling the key concept of rationality. The issue contributes to the debate on how rational young children's action perception and production is.

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