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The relation between mirror self-image reactions and imitation in 14- and 18-month-old infants



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ABSTRACT

Previous research suggests that sensitivity to aspects of the self and others develop in tandem. We tested 14- and 18-month-olds' imitative abilities and mirror self-image reactions (i.e., testing behavior and passing the mark test). Results showed that 14-month-olds' imitation was closely related to the occurrence of testing behavior in front of the mirror, where they checked whether they could control the movements of the mirror image. Eighteen-month-olds, however, no longer showed this relation. Furthermore, in 18-month-olds, we found a high association between imitation and passing the mark test. These correlations suggest that infants' mirror self-image reactions and imitation share the ability to detect and produce visual-motor contingencies.

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1. Introduction

Imitation plays a fundamental role in the evolution of human culture (Tomasello, 1999). Very early in ontogeny, infants learn and copy what they observe in their social environment (Barr, Dowden, & Hayne, 1996; Meltzoff, 1988). The extent to which they learn from others depends on a variety of context factors, for example a model's characteristics, such as age (e.g., Seehagen & Herbert, 2011; Zmyj, Daum, Prinz, Nielsen, & Aschersleben, 2012), a model's intentionality (Carpenter, Akhtar, & Tomasello, 1998), and the relevance of actions for achieving an external result (Brugger, Lariviere, Mumme, & Bushnell, 2007). It is taken for granted in this line of research that infants are able to imitate observed actions. However, it is still a matter of debate as to how an observed action is transferred into a motor signal (correspondence problem, Heyes, 2001). Since the mechanism for this transformation remains unclear, we refer to imitation as the reproduction of an observed action (Paulus, 2011). The term action refers to object-directed bodily movements as well as to bodily movements that are not directed to an object. In the present study, we investigated infants' imitation and mirror self-image reactions as two instances of observing and producing actions in order to explore whether they are related in development.

1.1. Visual-motor contingency and imitation

Many researchers have suggested that the correspondence problem can be solved by the human cognitive system, as action perception and action production share common representations in that perceived actions are represented in the same format as planned and performed actions (Prinz, 1997). Accordingly, the perception of an action primes its execution.

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This connection is already present in the first years of life (Daum, Prinz, & Aschersleben, 2011; Elsner, 2007; Hauf, Elsner, & Aschersleben, 2004). There are at least two accounts of how this link emerges so early in life. First, the nativist account of imitation suggests that a common link between action perception and action production is present from birth (Meltzoff & Moore, 1997). According to this idea, imitation builds upon the core human ability to represent actions from different modalities in the same supramodal format. This makes the correspondence problem obsolete. Newborns are thought to be able to imitate based on this mechanism (Meltzoff & Moore, 1977). However, there is still controversy as to whether a neonate's execution of a facial gesture (e.g., tongue protrusion), after having observed this behavior, is based on a direct link between perception and production of these actions (as suggested by Meltzoff & Moore, 1997) or whether this behavior is based on simpler mechanisms (Anisfeld, 2005). For example, infants protrude the tongue when they observe something interesting, and observing a protruded tongue is more interesting than observing an open mouth (Jones, 1996).

Second, the empiristic account of imitation suggests that imitation is the result of associative learning (Ray & Heyes, 2011). The basis for this associative learning is that the infant's execution of an action often coincides with the observation of the same action. Sources for this visual-motor contingency are watching one's own body moving directly or in reflecting surfaces, which additionally provide visual feedback of one's own actions that are not directly observable (e.g., facial gestures), and the imitative feedback of parents (Papoušek & Papoušek, 1979). Infants are able to detect contingency (i.e., the occurrence of one event increases the likelihood that another event will occur) very early in life (Bahrick & Watson, 1985; Rochat & Morgan, 1998; Striano, Henning, & Stahl, 2005). According to the idea of associative learning, imitation builds upon the experience of seeing and doing the same action at the same time (Ray & Heyes, 2011).

Despite the diverging viewpoints on the basis of imitation, both accounts suggest that learning is a viable foundation for how infants link self-generated actions to the corresponding visual and proprioceptive feedback. According to the nativist account of imitation, infants learn the relation between self-generated actions and the posture of different body parts via a so-called "body babbling", according to which infants randomly generate actions and monitor the corresponding afferent feedback (Meltzoff & Moore, 1997). Similarly, the empiristic account of imitation suggests that self-observation is a potential source for linking seeing and doing the same action (Ray & Heyes, 2011). An infant's ability to detect different forms of contingencies develops gradually over the first year of life for different modalities. At around 5 months of age, infants detect visual-motor contingencies (Bahrick & Watson, 1985; Schmuckler & Fairhall, 2001; Zmyj, Hauf, & Striano, 2009), and at around 10 months of age, they detect visual-tactile contingencies (Zmyj, Jank, Schütz-Bosbach, & Daum, 2011). Imitative abilities likewise develop gradually over the first years of life (Barr et al., 1996; Jones, 2007; Nielsen & Dissanayake, 2004). However, so far, the relation between contingency detection and imitation early in life has not been explored.

1.2. *Mirror self-image reactions and imitation*

When infants observe themselves in the mirror, they are able to experience the direct relation between self-generated actions and the corresponding contingent visual feedback. Before the age of 18 months, infants primarily observe the mirror self-image as they move their body or parts of it (Amsterdam, 1972) and engage in testing behavior by intentionally speeding up or suddenly stopping their movement in order to test whether the mirror self-image displays the same behavior (Bischof-Köhler, 1989). This testing behavior is an example of how infants monitor the visual consequences of self-generated actions. At around the age of 18 months, infants start to locate a mark on their cheek by using the mirror self-image in the so-called mark test (Amsterdam, 1972). The cognitive prerequisites for passing the mark test are still a matter of debate (for an overview, see Bard, Todd, Bernier, Love, & Leavens, 2006). Some researchers have suggested a high-level interpretation for this ability in the sense of a qualitative improvement in representational development. In other words, infants become capable of forming secondary representations in addition to forming primary representations (Bischof, 1996; Perner, 1991; Suddendorf & Whiten, 2001). Primary representations of objects are experienced as coming from the outside world and carry the tag of "reality" (Leslie, 1987). By contrast, a secondary representation of objects is conceived of as an imagination of objects which are automatically experienced as a mere copy of a real object (Perner, 1991). To succeed in the mark test, infants have to link their mirror image (i.e., primary representation) to their imagined self (i.e., secondary representation). Hence, the two types of representation need to be coordinated in order to recognize the fact that the mirror image reflects their own appearance.

This view, however, has been criticized by some researchers, who have suggested a low-level explanation for passing the mark test. For example, Heyes (1994) suggested that what has been described as mirror self-recognition is better described by the term "mirror-guided body inspection". It merely requires a differentiation between sensory input from the infant's own body and sensory input originating elsewhere. According to this explanation, individuals use the mirror to inspect the body without necessarily having a self-concept. Interestingly, even accounts that use a high-level interpretation of the mark test do consider this low-level explanation as a basis. It has been suggested that detecting contingencies between self-generated actions and the visual and proprioceptive feedback is the foundation for the later passing of the mark test (e.g., Rochat, 2003). Hence, testing behavior in front of the mirror and passing the mark test might lie along the same line of developmental progression. It should be noted, however, that this assumption still lacks empirical evidence.

Despite the controversy regarding the cognitive underpinnings of passing the mark test, it is assumed that advances in using the mirror image are related to advances in imitation of others (Ray & Heyes, 2011; Suddendorf & Whiten, 2001). Some empirical evidence has been obtained for this view. Passing the mark test emerges in tandem with imitation of actions (e.g., Asendorpf & Baudonniere, 1993; Asendorpf, Warkentin, & Baudonniere, 1996; Herold & Akhtar, 2008; Nielsen & Dissanayake,

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