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Infants' observation of tool-use events over the first year of life



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ABSTRACT

How infants observe a goal-directed instrumental action provides a unique window into their understanding of others' behavior. In this study, we investigated eye-gaze patterns while infants observed events in which an actor used a tool on an object. Comparisons among 4-, 7-, 10-, and 12-month-old infants and adults reveal changes in infants' looking patterns with age; following an initial face bias, infants' scan path eventually shows a dynamic integration of both the actor's face and the objects on which they act. This shift may mark a transition in infants' understanding of the critical components of tool-use events and their understanding of others' behavior.

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Introduction

Intentional actions begin—by definition—with a goal in mind and are dynamically monitored and adjusted to facilitate goal completion. In contrast, during observation of an action performed by another person, the actor's goal and intentions are not known. Rather, the goal needs to be inferred from the limited information available in the action stream. This leaves room for uncertainty, and

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different interpretations of the same action are possible (e.g., Dretske, 1988). For instance, seeing a person picking up a knife can lead to different interpretations of the intended goal depending on the context (e.g., a cooking show vs. a horror movie). Given enough contextual information, adults quickly form expectations by drawing on their extensive knowledge base acquired over time and are quite good at anticipating the most likely outcomes of observed action sequences (Zacks, 2004; Zacks, Kumar, Abrams, & Mehta, 2009; Zacks & Tversky, 2001). Furthermore, adults show numerous biases linking particular actions with specific types of mental states and dispositions (Iliev, Sachdeva, & Medin, 2012; Malle, 1999; Woolfolk, Doris, & Darley, 2006). Infants, in contrast, are still in the process of acquiring this knowledge and face more ambiguity when interpreting observed actions (e.g., Kuhlmeier, Wynn, & Bloom, 2003). In the absence of extensive experience, how do infants learn about the structure of observed action sequences?

Learning by doing

Infants' own actions play an important role in shaping their interpretations and understanding of observed actions (e.g., Gerson & Woodward, 2010; Hunnius & Bekkering, 2010; van Elk, van Schie, Hunnius, Vesper, & Bekkering, 2008). Correlational evidence for this view comes from studies showing that infants' own grasping skills are related to their ability to predict the goal of an observed action (Kanakogi & Itakura, 2011). Direct evidence comes from training studies where motor skills were selectively manipulated. For example, placing Velcro mittens ("sticky mittens") over the hands of pre-reaching infants allows them to experience successful reaching before they would normally engage in this behavior (Libertus & Needham, 2010; Needham, Barrett, & Peterman, 2002). Experiences of self-produced reaching using sticky mittens have been found to facilitate infants' comprehension of the goal and efficiency of observed actions (Skerry, Carey, & Spelke, 2013; Sommerville, Woodward, & Needham, 2005). Furthermore, reaching training with sticky mittens also fosters infants' perception of complex causal action events (Rakison & Krogh, 2012). Together, these findings suggest that infants learn about actions, their goals, and their structure from their own experiences. A similar position has been put forward in the mirror neuron hypothesis that links action production closely with action perception (Calvo-Merino, Glaser, Grezes, Passingham, & Haggard, 2005; Cannon et al., 2014; Umiltà et al., 2001).

Learning by observing

First-hand action experiences are clearly important for learning, but this is not the only way in which infants' understanding of observed actions grows over the first year of life. During a regular day, infants have multiple opportunities to observe others engage in goal-directed activities. Infants learn from such observations, and these experiences influence the development of infants' ability to parse goal-directed events (Esseily, Nadel, & Fagard, 2010). Critically, infants also observe countless actions performed by others that they cannot yet produce themselves. Are infants also able to learn from observation of such never produced actions?

There is evidence that infants can indeed learn from observation alone. For example, infants' observation of a series of visual images containing co-occurrences of certain stimuli and random variation in other stimuli allows them to learn the predictable pairings and respond when these pairings are broken (Fiser & Aslin, 2002). Infants could presumably learn in a similar way about pairings of others' actions and the outcomes of these actions (Buchsbbaum, Griffiths, Plunkett, Gopnik, & Baldwin, 2015; Stahl, Romberg, Roseberry, Golinkoff, & Hirsh-Pasek, 2014). Others have shown that infants can learn new skills by watching demonstrations of action sequences (Elsner, 2007; Elsner & Aschersleben, 2003), although the reliable performance of these skills appears somewhat later during the first year of life. For example, Esseily and colleagues (2010) used age-appropriate object retrieval tasks to test infants' ability to learn action sequences from demonstration and found a distinct improvement in sequence reproduction between 10 and 12 months of age.

Importantly, infants also seem to make some sense of observed actions they cannot perform themselves yet. For example, infants can parse adults' actions into meaningful units, including both main action events and transitions that occur between important landmarks in the flow of an action

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