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Infants learn enduring functions of novel tools from action demonstrations



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ABSTRACT

According to recent theoretical proposals, one function of infant goal attribution is to support early social learning of artifact functions from instrumental actions, and one function of infant sensitivity to communication is to support early acquisition of generic knowledge about enduring, kind-relevant properties of the referents. The current study tested two hypotheses, derived from these proposals, about the conditions that facilitate the acquisition of enduring functions for novel tools during human infancy. Using a violation-of-expectation paradigm, we show that 13.5-month-old infants encode arbitrary end states of action sequences in relation to the novel tools employed to bring them about. These mappings are not formed if the same end states of action sequences cannot be interpreted as action goals. Moreover, the tool–goal mappings acquired from infant-directed communicative demonstrations are more resilient to counterevidence than those acquired from non-infant-directed presentations and, thus, show similarities to generic representations rather than episodic ones. These findings suggest that the acquisition of tool functions during infancy is guided by both teleological action interpretation mechanisms and the expectation that communicative demonstrations reveal enduring dispositional properties of tools.

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Introduction

The material culture of *Homo sapiens* displays robustness and complexity unmatched in the animal kingdom. Our environment is populated with artifacts, and our goals are routinely attained with the help of different kinds of tools, which were designed and manufactured in order to facilitate bringing these goals about. Human adults conceptualize tools through their functions; that is, they tend to think about kinds of tools as being “for” achieving particular goals. Function is an enduring *dispositional* property of a tool to bring about a particular goal when used in an instrumental action. Consequently, function is an unobservable abstract feature whose relations to the available structural and behavioral information (e.g., observable physical features of a tool or its manners of use) are often cognitively opaque (Csibra & Gergely, 2006). Human children deal remarkably well with the considerable and unique challenge of acquiring knowledge of tool kinds in terms of their functions, and numerous attempts have been made recently to study experimentally the early developmental roots of these achievements during infancy (Baumgartner & Oakes, 2011; Brugger, Lariviere, Mumme, & Bushnell, 2007; Futó, Téglás, Csibra, & Gergely, 2010; Hunnius & Bekkering, 2010; Sommerville, Hildebrand, & Crane, 2008; Träuble & Pauen, 2007).

Learning tool functions is not just a necessary step in development of full-fledged adult-like tool use but also a key to categorization of artifacts (Kelemen & Carey, 2007) – that is, of a substantial portion of the human environment – as well as a key to online prediction of instrumental actions with tools and of their outcomes (Csibra & Gergely, 2007; Hunnius & Bekkering, 2010; Paulus, Hunnius, & Bekkering, 2011) – that is, of a substantial portion of human everyday activities. Thus, we can expect that the development of functional knowledge of tools is not necessarily tied to slowly emerging competencies to use tools (Greif & Needham, 2011; McCarty, Clifton, & Collard, 2001) and may have very early developmental bases. In adults, (a) function underlies categorization of tools (i.e., any given tool belongs to a kind in virtue of function, which is a property of both the individual tool and its kind), (b) tool–function mappings are exclusive (i.e., typically a tool has a single kind-defining function even though its physical structure affords attaining various goals), and (c) tool–function mappings are enduring (i.e., a tool maintains its kind-defining function when broken, not in use, or when temporarily put to a different idiosyncratic use). Recent studies have demonstrated attention to functional information for categorization of tools in 12-month-old infants (Träuble & Pauen, 2007), expectation of exclusive mappings between artifacts and their hidden dispositional properties in infants perhaps as young as 10 months (Futó et al., 2010; but see Casler, 2014, and Defeyter & German, 2003), and beginnings of endurance of function–tool mappings in 24-month-olds (Casler & Kelemen, 2007).

To learn the function of a tool, one can try finding out what it was *made for*. Even young preschoolers appreciate the importance of intended function when making functional judgments (Defeyter, Hearing, & German, 2009; Kelemen, 1999). However, because both designers and users of tools typically aim at maximizing efficiency of instrumental actions, function often can be reliably established by considering what the tool is *good for* (i.e., it can be inferred from the causal–mechanical affordances of the tool) or by observing what it is *used for* (i.e., it can be inferred from the goal of an observed instrumental action with the tool) (Csibra & Gergely, 2007). The latter route to function–tool mappings is of particular interest here for three reasons. First, it relies on the mechanisms of action understanding, which can support goal attribution (and consequently ascription of the function to the tool) despite the cognitive opacity of the causal relations that underlie the workings of the tool and its manner of use. Second, given human infants’ proficiency with goal attribution, learning what the tool is for by observing what it is used for may be a cognitive strategy available to human children already during infancy. Third, identifying the goal of an instrumental tool use demonstrated in a communicative context may allow infants to infer not only the idiosyncratic purpose that the individual tool serves on a particular occasion but also its enduring function, which for adults defines the tool kind (Hernik & Csibra, 2009).

The series of experiments presented in this article explore the conditions that facilitate the acquisition of enduring functions for novel tools during human infancy. Specifically, this research is motivated by the theoretical proposal that learning tool kinds and their functions is facilitated by two sets of cognitive skills: (a) the propensity for teleological action interpretation and (b) the ability to acquire generic information from ostensive communicative demonstrations. In the following sections, we discuss these theoretical claims in detail.

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