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How 24-month-olds form and transfer knowledge about tools: The role of perceptual, functional, causal, and feedback information



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ABSTRACT

This study investigated cognitive processes underlying tool use and knowledge transfer in 24-month-olds ($N = 123$). Following a demonstration, participants chose a tool to reach a reward in a training transfer paradigm. Differing from previous research, various aspects considered to be relevant for children's performance were integrated within the same study design, and performance was examined on a trial-by-trial basis. More specifically, we analyzed how the following aspects affected toddlers' learning and transfer performance: causal information, degree of conflict between perceptually salient and functionally relevant information, and feedback information. Children with access to causal information outperformed children without corresponding information during the training and transfer phases. Perceptual conflict had a negative impact on transfer performance. However, children were quickly able to correct their choices based on feedback. Results are discussed in the light of recent accounts on tool use understanding.

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Introduction

Problem solving in everyday life often involves the use of tools. We use tools as an extension of our bodies, enabling actions that might otherwise be hard to realize (Berger, Adolph, & Lobo, 2005; Connolly & Dalgleish, 1989). No other species uses tools as often or as flexibly as humans do

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(Bjorklund & Gardiner, 2011). But how does this ability develop? Which basic cognitive processes underlie the formation of knowledge about tools in young children, and which factors influence transfer of tool knowledge to new situations? The current article addresses these questions. Following a summary of recent evidence on the acquisition and transfer of tool knowledge during early childhood, we present a training transfer study on tool use conducted with 2-year-olds. In this study, we investigated the role of perceptual, functional, causal, and feedback information for toddlers' performance using an integrated study design.

Acquisition of tool knowledge during early childhood

Within their first year of life, infants become able to relate objects to each other in order to achieve a specific goal (e.g., Munakata, McClelland, Johnson, & Siegler, 1997; Piaget, 1954; Willatts, 1999). Basic perceptual information serves as a relevant cue to functional properties of artifacts at this age (Bates, Carlson-Luden, & Bretherton, 1980). For instance, the form of a hook is correlated with the functional feature of “pulling something into reach” (Brown, 1990). Thus, the form aspect becomes a functional attribute because it is related to achieving a specific goal. As demonstrated in multiple studies, children become sensitive to form–function relations early during their second year of life (Madole, Oakes, & Cohen, 1993; Träuble & Pauen, 2007, 2011). At roughly the same time, they also begin to use tools in everyday life, such as a spoon for eating (Connolly & Dalglish, 1989; McCarty, Clifton, & Collard, 2001).

In a study by Brown (1990), 18-month-olds were taught to pull into reach an attractive toy by using a tool with a hook-like ending. When a new set of tools was offered afterward, children were able to find the functionally correct tool by attending to form information while ignoring irrelevant other perceptually salient attributes such as pattern and color. Chen, Sanchez, and Campbell (1997) reported similar evidence for 13-month-olds using a simpler version of the same task. These studies suggest that even very young children are able to focus on functionally relevant information and to ignore perceptually salient attributes when learning about artifacts.

Understanding the causal relevance of this information may support this process, as suggested by Träuble and Pauen (2007, 2011). These authors found that 12-month-olds are able to categorize a set of complex artifacts according to a perceptually non-salient part, rather than according to overall similarity, following a short demonstration of its functional properties. Interestingly, this effect could be observed only if the demonstration revealed a causal relation between the functional part of the artifact and the effect to be produced. Presenting a non-causal event that related the functional part to the effect did not lead to comparable results. Taken together, these findings suggest that salient perceptual information and functional knowledge, as well as causal knowledge, play an important role for children's learning about tools from early on.

In the current study, we refer to *salient perceptual information* when we mean perceptual attributes of a given tool that are easy to perceive but irrelevant for achieving a specific goal. We speak of *functional information* if a given tool property is reliably associated with goal achievement, and we refer to *causal information* if it corresponds to the mechanism explaining the effectiveness of a tool. Functional information and causal information are related, but children may have access to functional information without knowing about the causal mechanism explaining the functionality of a given tool (see Träuble & Pauen, 2007, 2011).

Transfer of tool knowledge during early childhood

Different artifacts may serve as efficient tools to solve the same problem, and the same artifact may serve as a tool to solve different problems. Hence, tool use in everyday life requires the flexible adaptation of knowledge. This raises the interesting question of how young children transfer acquired tool knowledge to new situations.

Work on early knowledge transfer in analogical reasoning tasks seems to be highly relevant in this context. Corresponding studies with toddlers and preschool children demonstrate that understanding causal relations relevant for producing a given effect improves problem-solving performance (Brown, 1990; Pauen & Wilkening, 1997; Singer-Freeman, 2005). Based on such findings, Goswami (1991,

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