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The effect of prior experience on children's tool innovation

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ABSTRACT

Spontaneous tool innovation to solve physical problems is difficult for young children. In three studies, we explored the effect of prior experience with tools on tool innovation in children aged 4–7 years ($N = 299$). We also gave children an experience more consistent with that experienced by corvids in similar studies to enable fairer cross-species comparisons. Children who had the opportunity to use a premade target tool in the task context during a warm-up phase were significantly more likely to innovate a tool to solve the problem on the test trial compared with children who had no such warm-up experience. Older children benefited from either using or merely seeing a premade target tool prior to a test trial requiring innovation. Younger children were helped by using a premade target tool. Seeing the tool helped younger children in some conditions. We conclude that spontaneous innovation of tools to solve physical problems is difficult for children. However, children from 4 years of age can innovate the means to solve the problem when they have had experience with the solution (visual or haptic exploration). Directions for future research are discussed.

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Introduction

Tool use is considered to be a hallmark of human cognition, with our substantial technological accomplishments unrivaled by any nonhuman animal species. Observations of infants and children demonstrate their impressive competence in terms of their tool use and knowledge. From around 2 years of age, children show insight into the function of tools (Casler & Kelemen, 2005) and anticipate the target of a tool use action (Paulus, Hunnius, & Bekkering, 2011). In addition, 3-year-olds reliably copy tool use from peers (Hopper, Flynn, Wood, & Whiten, 2010) and are capable of transmitting a tool use action across multiple generations (Flynn & Whiten, 2008; Hopper et al., 2010). It is surprising, then, that despite being proficient tool users, children appear to struggle to innovate tools (i.e., to make a novel tool to solve a task) without prior training (Beck, Apperly, Chappell, Guthrie, & Cutting, 2011; Cutting, Apperly, & Beck, 2011; Cutting, Apperly, Chappell, & Beck, 2014; Hanus, Mendes, Tennie, & Call, 2011; Nielsen, Tomaselli, Mushin, & Whiten, 2014; Sheridan, Konopasky, Kirkwood, & Defeyter, 2016; Tennie, Call, & Tomasello, 2009).

Recent research into children's tool innovation was motivated by studies with corvids. "Betty," a captive New Caledonian crow, spontaneously manufactured a hook from a straight piece of wire to retrieve a wire-handled bucket from a transparent tube (Weir, Chappell, & Kacelnik, 2002). Researchers were investigating whether crows could choose the correct tool to solve a task and, on a task requiring a hook, had given them a hooked piece of wire and a straight piece of wire. When one crow flew off with the hooked tool, Betty bent the straight piece of wire to make her own hook despite not being shown how to make tools previously. In a later experiment, Betty continued to make functional hooks on the majority of trials when given only straight pieces of wire. New Caledonian crows have been directly observed making and using tools in the wild (Hunt & Gray, 2004; Rutz, Sugasawa, van der Wal, Klump, & St Clair, 2016), although not from wire or wire-like materials. However, similar findings have been replicated by Bird and Emery (2009) with captive rooks, a species that does not use tools in the wild. They were also able to select and manufacture the correct tool to solve the hook-making task used by Weir et al. (2002). Thus, it is even more surprising that children younger than 8 years demonstrate difficulty with similar problems requiring tool innovation.

In a paradigm adapted from the corvid literature, children were able to choose the appropriate tool to solve a problem requiring a hook (Beck et al., 2011). From 4 years of age, children were significantly more likely to pick up a hooked pipe cleaner than to pick up a straight one when their goal was to retrieve a handled bucket containing a sticker reward from a tube. However, when other children were given a straight pipe cleaner that required bending into a hook shape to retrieve the bucket, children younger than 5 years rarely solved the task. Performance improved with age, and it was not until 8 years that approximately half of children passed the task. Interestingly, most children found manufacturing a tool (making a tool following adult demonstration) comparatively easy. This finding appears consistent across cultures. Western and Bushman children show a similar pattern of tool innovation performance; innovating a tool independently to solve a physical problem is difficult for children aged 3–5 years, whereas manufacturing a tool following an adult demonstration is significantly easier (Nielsen et al., 2014).

Beck et al. (2011) noted that children's knowledge of tool function and ability to manufacture tools emerges significantly earlier than their ability to innovate tools. Given the findings from tasks involving corvids, children's difficulty with tool innovation has been met with curiosity. Given that many nonhuman species are known to use tools (Seed & Byrne, 2010), it is the human propensity for tool *innovation,* and the complex technologies that have arisen because of it, that sets us apart from nonhuman species. Findings such as these raise bigger questions surrounding human cognitive architecture. It is important to better understand those processes that we might share with nonhuman animals and those that may demonstrate human uniqueness (Shettleworth, 2012).

Cross-species comparisons between human children and nonhuman animals are often made (e.g., Beck et al., 2011; Cheke, Loissel, & Clayton, 2012; Engelmann, Herrmann, & Tomasello, 2012; Taylor et al., 2014). However, caution is required. To truly understand how human children differ from other species, in this case corvids, it is vital that studies are methodologically sound and fair to both species (Boesch, 2007; Shettleworth, 2012). When experimental procedures systematically differ, the value of