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The role of conventionality and design in children's function judgments about malfunctioning artifacts

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ABSTRACT

This study investigated the individual influences of conventionality and designer's intent on function judgments of possibly malfunctioning artifacts. Children aged 4 and 5 years and 6 to 8 years were presented with stories about an artifact with two equally plausible functions, one labeled as either conventional or designed. Subsequently, a character attempted to use the artifact for the cued function, which resulted in either malfunction or successful use. The children's task was to identify the real function of the artifact. When the use attempt succeeded, 4- and 5-year-olds preferred conventional functions to the alternative (but did not show a clear preference between design functions and the alternative), and 6- to 8-year-olds preferred conventional and designed functions to the alternative. In case of malfunction, children's choices were at chance, where the effect of either conventional or design cues was less salient. This contrasts with a baseline condition where children avoided the malfunctioning alternatives. Presenting additional cues about an artifact's function can affect function judgments in cases of malfunction.

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Introduction

A key feature of human societies is the presence of technological traditions. Different cultural groups develop and impart future generations with a vast array of tool-use methods that are suited to their living environment and cultural lifestyle. This process involves a "dual engine" that fosters the acquisition of conventional norms and the acquisition of instrumental knowledge about tool functions (Legare & Nielsen, 2015). In particular, the former focuses on information about how to use an object, often based on conventional cues, and the latter focuses on design cues. This study aimed at documenting the role of conventional and design cues in children's conceptualization of a true function of an artifact.

Imagine cataloging novel objects found in a storeroom. A common approach would be to categorize them according to their instrumental functions based on the outcome they likely bring about (Csibra and Gergely, 2007; Hernik & Csibra, 2009). Indeed, adults have been shown to use the originally intended function as a basis for identifying artifacts regardless of how they might be currently used (e.g., an old mug used as a pencil holder will still be called a mug) (Barrett et al., 2008; Chaigneau et al., 2008; Chaigneau & Puebla, 2013; Defeyter et al., 2009; Siegel & Callanan, 2007). This *design stance* involves the development of a theoretical construal of artifacts where a tool is treated as intentionally designed for a purpose based on properties that are specific to that purpose (Bloom, 1996, 1998, 2000; Kelemen & Carey, 2007). For example, we will likely assume a "J"-shaped artifact to be used for carrying or holding something and thus categorize it broadly as a "hook." The former process of identifying design functions emerges early around the toddlerhood to preschool years (Bloom & Markson, 1998; Diesendruck et al., 2003; Gelman & Bloom, 2000; Kelemen, 1999; Oakes & Madole, 2008), but the latter process of categorization only fully develops at around 7 years of age (Truxaw et al., 2006).

By 4 years of age, children become sensitive to artifacts' characteristics, presumably decided by the designer, that are optimally suited for achieving an instrumental outcome (Kelemen et al., 2012). With this basis, children start to associate intentionally designed functions with intended outcomes and exclude other possible alternatives. In Kelemen (1999), when 4- and 5-year-olds were told that a novel artifact was designed to perform a function (e.g., stretch out clothes) but was used for another purpose (e.g., exercise the character's bad back), children favored the design function over the current function. At the same time, they also start to habitually identify socially preferred functions and uses of artifacts (Casler et al., 2009; Dahl & Schmidt, 2018) and will use them for the same function consistently even after being exposed to an alternative (Casler & Kelemen, 2005, 2007). They will rely on information agreed on by the majority to attribute specific functions to various objects (Corriveau et al., 2009) and are sensitive toward linguistic cues when making imitation decisions (e.g., copying a method verbally labeled as normative even when it is less effective; DiYanni et al., 2022). These are likely driven by social motives for children to adopt conventional methods of tool use that are coherent with their cultural ingroup (Fong et al., 2023; Nielsen, 2018; Over & Carpenter, 2012).

Although both design and conventional cues guide children's conceptualization of artifacts, they do not blindly process these cues. Existing literature suggests that preschool children's artifact representation is not restricted to the intentions of the designer but more broadly is centered by information about plausible goals an artifact can be used to achieve (Defeyter & German, 2003; German & Johnson, 2002; Truxaw et al., 2018). In Schillaci and Kelemen (2014), young children avoided less plausible ways of using certain tools (e.g., using a spiral egg holder to carry orange juice) even when these ways were endorsed by the majority. Similarly, in an imitation study about ineffective tool use, 4-year-olds did not copy the use of a nonaffordant method (e.g., using a soft pom-pom tool to crush a cookie) neither when it was labeled as the one intended for the task nor when it was shown to be the socially preferred method (DiYanni & Kelemen, 2008). This early intuition into tool functions likely emerged to prevent the transmission of misconceptions or misuse of objects, which in turn can stymie technology (Dean et al., 2014; Laland, 2004).

What remains unclear is whether exposing children to cases of malfunction will sway them away from acknowledging that function as a real function of an artifact. Some hints come from a study by

Chaigneau and Puebla (2013) in which adults were presented with a novel mountaineering device that served two equally plausible functions: abseiling (to prevent falling while ascending) and belaying (to control descending by using friction). They learned about a specific episode showing an accidental event while an adult was using it for one of these functions, framed as either designed, conventional, both designed and conventional, or neither designed nor conventional. When asked to judge the function of the artifact, participants chose the function involved in the accident only when it was framed as design but not conventional. Thus, in this case, presenting a conventional function was vulnerable to potential pitfalls, whereas the design function allowed a robust assignment of proper function when confronted with conflicting evidence.

The current study

We sought to evaluate the relative importance of social conventions compared with designers' intentions in children's function judgments. We were also interested in whether or not presenting such information would prevent children from devaluing a function based on possible malfunctions. This study adapted the paradigm employed by Chaigneau and Puebla (2013) and incorporated stimuli used in previous research (Defeyter et al., 2009). Children were first presented with stories about an artifact that could be used in two equally plausible ways, one of which was labeled as either a conventional function (i.e., "everybody uses") or a design function (i.e., "it is made for"). The story continued with a new character using the artifact for the cued function (i.e., the conventional or design function), which resulted in either malfunction or successful use, followed by a successful use of the alternative function. At the end of the story, children were asked what the artifact was for.

To measure what characterized children's approach to the experiment manipulations based on their knowledge independent of the conventional or design cues, we included a baseline condition without information about conventionality or design but only the malfunction episode. We predicted that in the baseline condition the malfunction episode would render the critical function to be less plausible, driving participants to choose the alternative function, whereas in the experimental conditions framing the artifacts with design or conventional cues would strengthen those same functions, alleviating the effect of malfunction episodes.

Method

Participants

A total of 150 children were recruited and tested through a primary school (n = 20) or a university laboratory (n = 130). They were divided into two age groups: a younger group of 80 4- and 5-year-olds (39 girls; M = 4.50 years, SD = 0.50, range = 3.90–5.50) and an older group of 70 6- to 8-year-olds (34 girls; M = 6.70 years, SD = 0.50, range = 5.90–7.90). An additional 9 children were tested but not included in the main analyses due to experimental error (n = 3), failing the control questions (n = 4) or noncompliance (n = 2). Children's demographic details were not collected at the time of test. Related studies have documented that children recruited in similar studies are predominantly Caucasian, with a minority being of Asian and African backgrounds. This study met the requirements of the National Statement on Ethical Conduct in Human Research of 2007 (current revision) and was approved by the University of Queensland health and behavioral sciences low and negligible risk ethics board. All children received parental consent to participate in the study and received a small gift at the end of the session.

Materials and procedure

Testing was undertaken with the experimenter sitting opposite the child at a table, with an iPad facing the child placed approximately 50 cm equidistant between them. All illustrations were presented on the iPad. The stimuli consisted of line drawings adapted from a previous study (Defeyter et al., 2009) outlining two equally plausible functions for four novel artifacts along with possible mal-

function episodes (see Table 1). The order of tools and functions and the specific function assigned to each role (critical or alternative) were counterbalanced between participants. As our manipulations for conventionality and design, we employed pictures of a group of people, a female designer and a male designer, and four female users and four male users (see Fig. S1 in online supplementary material). To control for possible gender-based biases, the gender of the characters involved in the stories was matched with the children's gender.

Children were randomly assigned to one of the following four experimental conditions and one baseline condition in which every child was presented with stories of each tool use (four trials in total).

Convention with malfunction

One of the functions was described as conventional, and the other function was described as possible but not being used by anyone. After this there were two memory check questions about the functions. If a child answered incorrectly, the story was repeated and the child was asked once more. If the child failed a second time, he or she was replaced. Then, a new character tried to use the tool for its conventional function but failed. After this the character used the tool for the alternative function successfully. Participants were then asked to indicate which of the two functions was the real function. (see Fig. S2 for a script example).

Convention without malfunction.

This condition was identical to the previous one except that there was no malfunction episode.

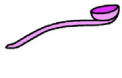
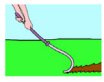
Design with malfunction

This condition was identical to the convention with malfunction one except that the critical function was described as designed instead of conventional (e.g., X made it for Y; X did not make it for Z).

Design without malfunction

This condition was identical to the previous one except that there was no malfunction episode.

Table 1
Functions and malfunctions across four tools.

Tool	Function A	Malfunction A	Function B	Malfunction B
Dax	Throwing balls	Ball gets stuck in the dax	Digging in the sand	Sand gets stuck in the dax
				
Tog	Grabbing fruits from trees	Fruits slip under the top	Breaking the soil	Soil is too hard
				
Toma	Catching fish	Fish jump out of the toma	Carrying bottles	Bottles fall out of the toma
				
Zig	Gathering fruits	Fruits fall out of the zig	Sliding in a rope	Zig gets stuck in the rope
				

Baseline

This condition was identical to the malfunction conditions except that both functions were established as possible without any reference being made to conventionality or design. Thus, no memory check questions were included.

Coding

For the four experimental conditions, participants received a score of 1 each time they chose the cued function and a score of 0 otherwise. As for the baseline condition, participants received a score of 1 each time they chose the function that was associated with a malfunction episode and a score of 0 otherwise. Thus, the total score for each participant ranged from 0 to 4.

Results

Preliminary analysis showed that the order of the tools, the order of the functions, the role of each function, and gender had no main effects on participants' responses and did not interact with the experimental manipulations. These variables were not considered further.

A 5 (Condition: convention with malfunction, design with malfunction, convention without malfunction, design without malfunction, or baseline) by 2 (Age Group: 4- and 5-year-olds or 6- to 8-year-olds) analysis of variance (ANOVA) revealed a main effect of condition, $F(4, 140) = 9.87$, $p < .01$, $\eta_p^2 = .22$. The main effect of age group and the interaction were not significant (Fs < 1).

Because of a priori predictions about developmental changes, we conducted a series of two-tailed, one-sample t tests against chance (defined as a score of 2 out of 4) to evaluate every condition in each age group. The baseline scores for both age groups were significantly below chance, suggesting that all children avoided the function involved in the malfunction episode when there was no information about conventionality or design. For both age groups, their scores in the convention without malfunction condition were above chance, indicating that conventional information played a role in functional judgment. Younger children's critical function scores in the design without malfunction condition were at chance, whereas those of 6- to 8-year-olds was above chance. This indicates that, unlike conventional cues, design information only affected older children, but not younger children, by inducing a preference for the critical function. For conditions that involved malfunction episodes, regardless of the type of cues or age group, all children's preferences were at chance (see Table S1 in supplementary material). They did not show a preference for either of the two tool options presented. This indicates that children's function judgment in the face of possible malfunctions was affected by either the conventional or design cues in relation to their preference for viable alternatives when there was no cue (as shown in the baseline condition). See Fig. 1.

Discussion

Using artifacts is an essential part of our daily lives. Children rely on design information to guide them in choosing which tool to use and how to do so effectively for a specific purpose (Bloom, 1996; Kelemen, 1999). At the same time, they also use conventional information to ensure that tools are used according to the normative way (Siegel & Callanan, 2007). Previous research (e.g., Defeyter et al., 2009; Siegel & Callanan, 2007) revealed that preschool children did not display a bias between a conventional function and a design function when both were pitted against each other. This study evaluated the role that conventional and design cues may individually play in children's function judgments of novel artifacts. We were also interested in whether presenting certain pitfalls would devalue a piece of design or conventional information. The current results suggest that both social conventions and designers' intentions are important parts of children's identification of artifact functions even when these cues are pitted against potential malfunctions.

When there was not a malfunction episode, younger children (4- and 5-year-olds) preferred conventional functions to alternatives; however, they responded at chance levels when the choice was between a design and a possible alternative. For this age group, only conventional cues, but not design

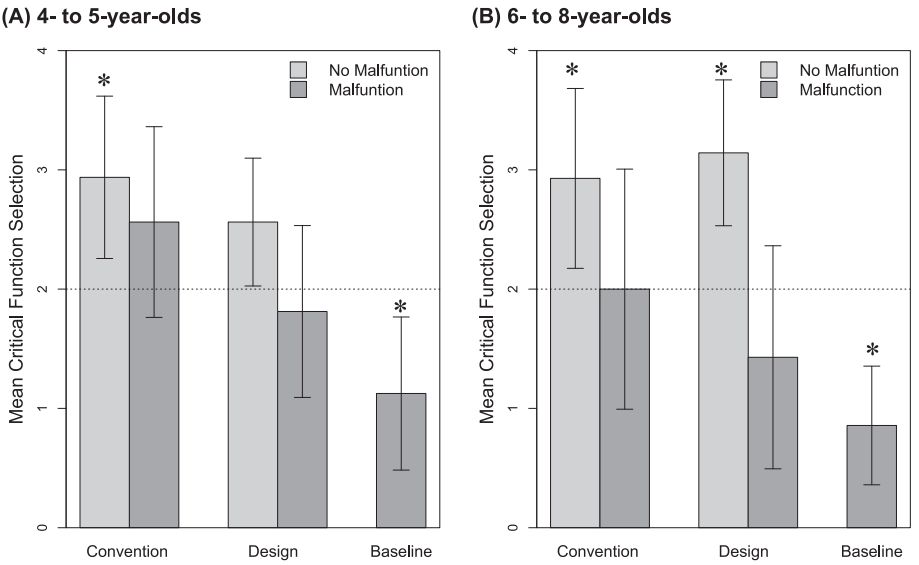


Fig. 1. Mean number of critical function selections for each condition in each age group. *Significantly different from chance (50%), $p < .05$. Error bars represent 95% confidence intervals.

cues, elicited a preference for the cued tool over the alternative. Intriguingly, older children (6- to 8-year-olds) preferred either the conventional or design functions over possible alternatives. This difference between the two age groups points to an early primacy of social conventions in children's function judgments. This supports the notion that children only start to display adult-like judgments around the primary school years, categorizing artifacts based on the design stance (German et al., 2007; Hernik & Csibra, 2009; Matan & Carey, 2001; Oakes & Madole, 2008). However, our next finding suggests that older children do not yet process the interplay between design cues and malfunctions at an adult level.

Presenting instances of malfunctions modulated the influence of both conventional and design cues, although only reducing children's preference to chance level for both age groups. In the baseline condition without either of these cues, children avoided the functions that displayed potential malfunctions. This contrasts with adult results in an analogous study where design cues, but not conventional cues, were able to support stable function assignment in the face of conflicting pitfalls (Chaigneau & Puebla, 2013). Integrating these results together yields a picture where initially conventionality plays a more central role in children's function judgments and later designer's intention comes to be the leading factor in defining the proper function of an artifact. What remains uncertain is why conventional and design functions show resistance to the conflicting evidence provided by a malfunction episode. We speculate that this resistance effect is potentially related to the one tool–one function mapping expectation that seems to be in place from around 2 years of age (Casler & Kelemen, 2005, 2007).

The resistance effect induced by conventional or design cues found in this study may be analogically similar to functional fixedness—fixation of an identified function or goal that an object can achieve, neglecting or not accepting other viable alternatives (Adamson, 1952). However, previous studies found that only 7-year-olds, but not younger children, display functional fixedness (e.g., Defeyter & German, 2003). Furthermore, previous studies on functional fixedness have focused on "typical functions," where what underpins the concept of "typical" remains underexplored. The effect of conventionality and design stance on children's function judgment may serve as early onset of functional fixedness. Future investigations could employ a within-participant design to test how, at an individual level, children process design stance and conventionality in relation to their spontaneous

non-cued judgment. This should further clarify how the two cues may play in tandem to form children's conceptualization of tool functions and functional fixedness.

A potential limitation of this work is the use of artificial stimuli. Although this allowed strict control over a number of possible confounding variables (e.g., perceived efficiency and saliency of the functions used) and standardization of stimuli presentation, it also limits the extent to which these results can be extrapolated to real tool-use situations. Future research should aim to replicate the current findings using tangible objects instead of drawings of artifacts. A further limitation is that we did not include contrasting cultural communities in our testing, and hence it is possible that the results presented here are not generalizable. Reflecting continued calls for developmental psychology to expand data collection beyond the WEIRD (Western, educated, industrialized, rich, and democratic) communities (Henrich et al., 2010) that characterize it (Amir & McAuliffe, 2020; Draper et al., 2022; Nielsen et al., 2017), a deeper understanding of the ways in which conventionality and designer's intent influence children's judgments of artifact function will come from taking this design to other populations.

Humans' propensity for generating technological traditions is a phenomenon unparalleled in the animal kingdom. One of the distinctive features that set our tool use apart is that we use different artifacts for very specific purposes. This is supported by the cognitive ability to attribute lasting and specific functions to artifacts. By making either social conventions or designers' intentions to interfere with normal information processing about artifact use, we have shown that these are two important components of children's conceptualization of the artifact functions. Based on this premise, future empirical research and theorization on how children process the interplay between conventionality and design stance promise to shed light on the ontogeny of artifactual concepts.

CRediT authorship contribution statement

Frankie T.K. Fong: Writing – original draft, Writing – review & editing. **Guillermo Puebla:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Mark Nielsen:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2023.105835.

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