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Time to get a new mountain? The role of function in children's conceptions of natural kinds

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Abstract

Prior research indicates that young children are promiscuously teleological, attributing purpose not only to artifacts, but also to living and non-living natural entities. This study further examines the role of function in children's reasoning about different object kinds by indirectly probing children's intuitions about what types of entities can be rendered functionless. Specifically, children were asked to decide whether entities that could no longer perform certain activities should be fixed/replaced (e.g. "Do you need to get a new one?"). Results reveal that young children broadly view both artificial and natural kinds that can no longer perform certain activities as needing to be fixed or replaced. These findings suggest that the teleo-functional bias not only influences children's explanatory preferences but also their category judgments.

Keywords: Function; Artifact; Teleology; Nature

Piaget's claim that children are profoundly confused about the distinction between artifacts and naturally-occurring entities has provoked a substantial literature over recent decades given its implication of fundamental incommensurability between child and adult cognition (Piaget, 1929). Contrary to Piaget's proposal, however, contemporary studies find that, by kindergarten, children distinguish artifacts and natural kinds in various ways, recognizing that, for example, people make artifacts but not natural entities (e.g. Gelman & Kremer, 1991), and that unlike most artifacts, living things self-generate movement (e.g. Massey & Gelman, 1988), have more complex insides (e.g. Gelman & Wellman, 1991),

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have different mechanics of reproduction (e.g. Springer & Keil, 1991), and have the capacity for growth (e.g. Rosengren, Gelman, Kalish, & McCormick, 1991). Perhaps most important are findings suggesting that, at least by second grade, children distinguish natural kind categories as more elaborately structured than artifact categories, with essentialist intuitions promoting greater numbers of inductions about basic-level natural kinds (e.g. plants) than artifacts (e.g. crockery) (Gelman, 1988; also Keil, 1989).

However, in addition to studies emphasizing young children's adult-like sensitivities to distinctions between artifacts and natural entities, post-Piagetian research still indicates some striking developmental differences. One source of difference concerns teleo-functional intuitions about purpose. Specifically, a central constraint on adults' reasoning about artifacts (e.g. chairs) and biological properties (e.g. eyes) is the assumption that they exist to perform functions, with the distinction that while artifact functions are usually presumed to benefit external agents, body part functions are presumed to benefit organisms possessing them (Keil, 1992, 1995; Kelemen, 1999b). Importantly, however, adults tend not to extend teleo-functional intuitions of any kind to non-living natural kinds and their properties (e.g. craggy mountains), with the result that their activities (e.g. providing an animal habitat or natural defense) are seen as epiphenomena of their mechanical formation rather than any explanation for why they exist. In short, Western-educated adults carve up the living and non-living natural domains along teleo-functional lines, with subtle intuitions about function also conceptually demarcating the domains of artifacts and living things. By contrast, recent research indicates that, until around 9 years of age, children broadly treat entities of all kinds—artifacts, living and non-living natural kinds and their properties—as existing for a purpose, often deviating from adult intuitions about the kinds of functions entities perform (e.g. Kelemen, 1999b; Kelemen & DiYanni, 2005; but see Keil, 1992, 1995). Evidence of this promiscuous teleological bias comes from various sources.

For example, in one study, preschoolers were asked to help a puppet become wiser by telling him when he was asking "silly" questions or "questions that have no answer." After a training session with unrelated "silly" questions, the puppet showed children pictures of artifacts, living and non-living natural kinds and asked them what the entity or one of its properties was "for" (e.g. "what's the lion for?"; "what's the leg for?"). Despite displaying abilities to withhold functional responses, children differed from adults by assigning functions to almost every kind of object and part. Since these were often odd to adult ears (e.g. tigers are "for walking around" and "going in the zoo," mountains are "for climbing"), a forced-choice task then examined whether children really viewed these as teleological functions that the objects were "made for" or just activities they "could do or be used to do." Once again, this study found that in contrast to adults' selective responses, children were promiscuously teleological, adopting the view that objects of all kinds are "made for something" and that is "why they are here" (Kelemen, 1999a).

Subsequent studies using explanation choice methods have also established that these kinds of intuitions extend into elementary school. In one study, adults and 7- to 10-year-old children were asked to explain the properties of prehistoric animals (e.g. flat feet) and non-living natural kinds (e.g. grainy sand), by choosing between physical-causal explanations (e.g. "the sand was grainy because bits of shells got broken up making it that way") and teleo-functional explanations (e.g. "the sand was grainy so that it wouldn't

get blown away by the wind"). In contrast to adults and 10-year-olds, who actively endorsed teleo-functional explanations with biological properties only, 7- and 8-year-old children preferred teleological explanations for both living and non-living natural kind properties, with younger children endorsing "biological" self-serving and "artifact" other-serving functions for both entity types (Kelemen, 1999b, 2003). To summarize, various methods currently provide converging evidence that young children possess broad teleo-functional intuitions. However, one concern that can be raised about these studies is that they assess children's teleo-functional reasoning rather directly, either by asking children about the functions of entities (e.g. Kelemen, 1999a) or asking them to choose between teleo-functional versus other explanations (e.g. Kelemen, 1999b). With the latter method in particular, children's tendency to endorse teleo-functional accounts for both biological and non-biological natural kind properties might occur for various reasons. One possibility is that young children do not draw as robust a distinction between artifacts and naturally-occurring entities as adults explicitly do, and instead treat objects of all kinds as "designed functional entities"—perhaps because they overextend their knowledge of artifacts. However, another possibility is that children *do* draw a stringent distinction between different kinds, but promiscuously endorse teleological explanations because they are attracted by their Panglossian implications of natural order (i.e. "all is for the best in this the best of all possible worlds" Voltaire, 1759/1957). Thus their tendency to endorse teleo-functional statements is purely an explanatory bias, only occurring when children are asked unusual questions about objects and otherwise not entering into their everyday conception of, or dealings with, entities such as rivers and mountains, which they ordinarily categorize as non-functional entities.[1]

The current study explores these possibilities. It examines the role function plays in children's conception of different kinds through the indirect route of probing related intuitions regarding an entity's potential to be rendered functionless. For adults, an artifact that is still in one piece but has been rendered functionless (e.g. a vacuum cleaner that can no longer suck up dirt) is "broken" and in need of replacement or repair. This study therefore asks the following question: If young children really believe that a cloud exists "for" making rain, do they view a cloud that can no longer produce rain as much in need of replacement/repair as a functionless hoover? If children's teleo-functional preferences are more of an explanatory effect, it would be expected that, like adults, they will view it as a category error to say that a cloud needs to be fixed or replaced under these circumstances.

1. Method

1.1. Participants

Participants were 15 5- to 6-year-olds (10 boys and 5 girls; range 5–0 to 6–5; $M = 5–6$; "young children"), 17 7- to 9-year-olds (8 boys and 9 girls, range 7–10 to 9–6; $M = 8–2$;

[1] It should be noted that this possibility is not trivial, raising numerous questions as to why such a conceptual disjoint should exist and how such a robust explanatory bias becomes established.

"older children") and 16 college graduates ("adults"). An additional 4 younger children and 1 older child were tested but their data were excluded because they exhibited a "yes" response bias by answering "yes" to all experimental and control items.

1.2. Materials

Stimuli were 11 sets of laminated drawings: 3 artifacts, 4 living things, and 4 non-living natural kinds. Each set included one picture in which the object was engaged in a characteristic activity and one in which it was not. Adults completed a written version of the task without pictures.[2]

1.3. Design and procedure

Children were told that they were going to be asked some questions, that there were no wrong answers, and they could simply answer "yes" or "no." They were then presented with each picture set and asked if a depicted item would need to be fixed/replaced if "something happened so that" the item could no longer perform certain activities. For example, for one artifact set, children were shown two pictures of a vacuum cleaner, one in which it was sucking up dirt and one in which it was not. After highlighting the first picture (e.g. "Here is a picture of a vacuum cleaner sucking up dirt"), the experimenter pointed to the second picture and said, "Now, you can see here that the vacuum is not sucking up dirt. If something happened so that a vacuum could no longer suck up dirt, would you need to get it fixed/get a new one?" The "get it fixed/get a new one" phrase was intoned so that children would hear it as one unitary statement in which "get a new one" amplified the idea of "getting it fixed." All children interpreted the statement as one "yes/no" query. The wording was derived from exploratory work with preschoolers in which children spontaneously generated the phrase when talking about functionless items. The wording therefore served as an alternative to asking children whether different kinds of objects could be "broken" (e.g. "If something happened so that a vacuum could no longer suck up dirt, would you say it was "broken?")—an ambiguous term that pilot work (DiYanni & Kelemen, 2002) indicated was problematic because it can imply "in pieces" as well as "rendered functionless."

Table 1 presents the items. Many of the "functions" were those generated by children in prior research probing them about whether objects have functions (Kelemen, 1999a).

In order to track for indiscriminate "yes" biases, a control item set was included for each category tested. These control trials used wording similar to the test trials, except that the items did not need to be fixed/replaced according to adult intuition because the item was only temporarily inoperative. For example, a television set had "something happen" so that it became unplugged and no one could watch shows on it.

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[2] Adults were tested before children, and their items were the same except for the cloud item, which was added to children's battery to increase the number of non-living natural kind trials. Proportion scores are used in analyses to control for the fact that adults received 10 items and children received 11 items.

Table 1
Experimental items and their "functions"

Items	"If something happened to × so that it could no longer…, would you need to get × fixed/get a new one?"
Artifacts	
Hammer	Hit nails into wood
Vacuum	Suck up dirt
TV (control)	(came unplugged so that you could no longer) watch shows on it
Non-living natural kinds	
Mountain	Be climbed on
Wind	Blow
Cloud	Make rain
Moon (control)	(went behind a dark cloud so that you could no longer) see it shining
Living things	
Lion	Run around
Cat	Play around
Tree	Make shade and keep us cool
Bird (control)	(became sleepy so that it could no longer) fly

Trials were tested in random order although control sets and sets from one category never appeared consecutively.

2. Results

In order to check that children were making discriminations between items, a preliminary 2 (trial type: experimental vs. control) × 3 (age: younger vs. older vs. adults) ANOVA was conducted to compare the number of times participants judged items as needing to be fixed/replaced in the control versus experimental trials. Proportion scores were used to control for varying numbers of stimulus sets in the different categories and age groups. The analysis revealed a main effect of age, $F(2, 45) = 16.49$, $P < 0.001$, and a main effect of trial type, $F(1, 45) = 112.19$, $P < 0.001$, but, importantly, no age by trial type interaction. Children were generally more likely than adults to judge items as needing repair/replacement but, across all age groups, participants were more likely to say that experimental items rather than control items needed to be fixed/replaced. As Fig. 1 shows, both groups of children were significantly above chance at judging experimental items as needing to be fixed/replaced, $t(14/16) = 2.81$–4.20, both P's < 0.02, but all ages were significantly below chance at assigning the same judgment to control items, $t(14–16) = 3.30$–4.24, P's < 0.01.

A further 3 (age) × 3 (entity type: non-living natural kinds vs. living things vs. artifacts) ANOVA was conducted on the experimental trials to explore each age group's tendency to view the different categories as needing repair/replacement. Proportion scores were used and results are depicted in Fig. 2. The analysis revealed main effects of age, $F(2, 45) = 15.01$, $P < 0.001$, and entity type, $F(2, 90) = 40.33$, $P < 0.001$, that were subsumed by an age by entity type interaction, $F(4, 90) = 4.98$, $P < 0.002$.

Post-hoc analyses of the interaction revealed that while all age groups had the equivalently strong sense that artifacts that have been rendered functionless need

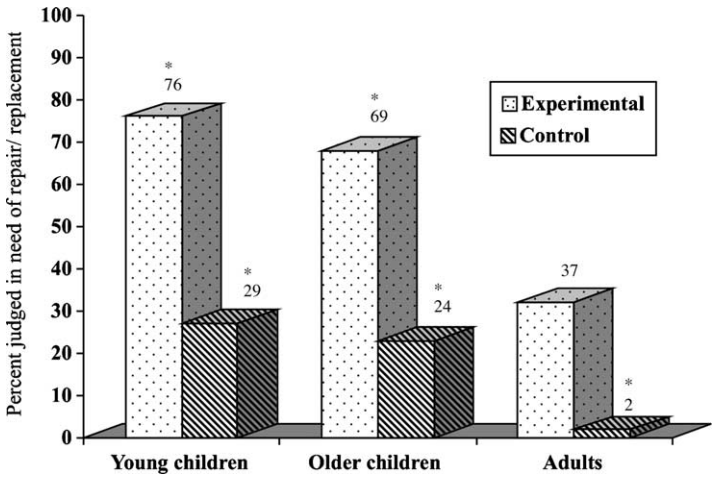

Fig. 1. Mean percentage of times items in each trial type (control vs. experimental) were judged in need of fixing or replacement. Different from change,*$P<0.02$.

repair/replacement, younger and older children were significantly more likely than adults to also make this judgment about non-living natural kinds and living things, Fishers LSD tests, $P<0.05$. Specifically, *t*-tests against chance revealed that although adults treated it as a category error to say that living and non-living natural kinds should be fixed/replaced, children did not, with both age groups endorsing it at above chance levels for living things

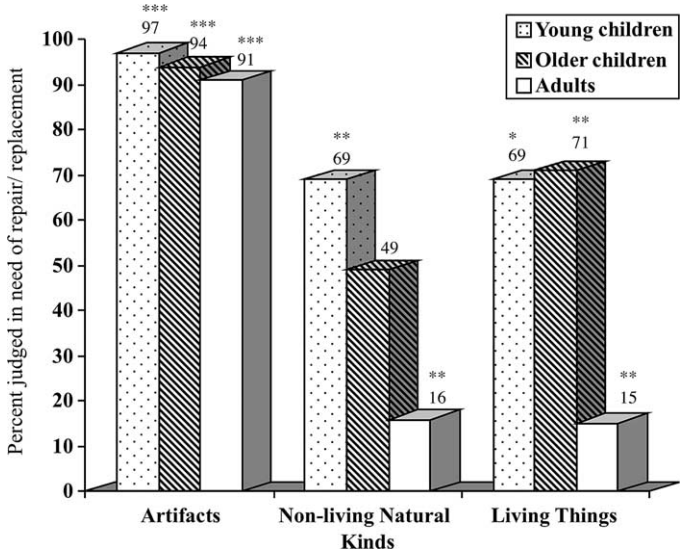

Fig. 2. Mean percentage of times each kind of entity was judged in need of fixing or replacement. Different from chance, ***$P<0.001$, **$P<=0.05$, *$P<0.05$, one-tailed.

Table 2
Percentage of individuals in each age group stating that items within each category needed to be fixed or replaced

	Young children				Older children				Adults			
	Never (%)	One (%)	Two (%)	Three (%)	Never (%)	One (%)	Two (%)	Three (%)	Never (%)	One (%)	Two (%)	Three (%)
Artifacts	0	7	93	N/A	0	12	88	N/A	6	6	88	N/A
Natural kinds	7	27	20	47	29	24	18	29	81	6	13	N/A
Living things	13	20	13	53	12	12	29	47	75	13	6	6

and only older children becoming ambivalent when asked about non-living natural kinds, all significant *t*-tests, $P < 0.05$, one-tailed.

The patterns were confirmed by individual patterns of response. As Table 2 shows, while most individuals in all age groups judged all "functionless" artifacts as needing repair/replacement, far more younger and older children than adults applied the judgment to all living thing items, Fishers Exact test, P's < 0.02. While 67% of younger children made the "fixed/replaced" judgment on two or more non-living natural kind items, older children were more divided.

3. Discussion

The present results suggest that, in contrast to adult responses, young children broadly construe artifacts and natural phenomena as susceptible to being rendered functionless and therefore in need of repair/replacement. This finding converges with prior evidence (e.g. Donovan & Kelemen, 2003; Kelemen, 1999a, 1999b; Kelemen & DiYanni, 2005) suggesting that until around 9 years, children display a promiscuous teleological tendency to view objects of all kinds existing for a purpose—a bias that the current findings suggest operates beyond the level of explanatory preference. These findings also converge with prior evidence suggesting that while young children are sensitive to a number of the dimensions along which artifacts, living, and non-living natural kinds differ, 5- and 6-year-olds, in particular, do not robustly draw certain adult-like distinctions between these categories, incorporating the notion of function into them all, while at the same time discriminating function as more central to artifacts than to naturally-occurring entities.

Of course, one possible objection to this interpretation is the suggestion that the current results primarily reflect semantic effects. Perhaps children were simply judging that if a cloud could not make rain, someone should "get a new one/fix it" because—without any particular commitment to whether or not clouds have functions—children thought the terms as good as any to describe the fact that the entity was unable to perform a characteristic activity. However, children's responses mitigate against this interpretation. First, children at both ages were less likely to label control rather than experimental items as needing repair/replacement, despite the fact that both kinds of items were unable to perform characteristic activities. Second, insofar as they considered them most

susceptible to being in need of repair or replacement, both groups of children distinguished artifacts as the most "functional" category of objects, a discrimination that presumably would not have occurred if children were applying "fix/replace" judgments wholesale to instances where they recognized objects as deviating from a norm.

In conclusion, recent research has, perhaps, tended to over-emphasize similarities in children's and adults' approach to classification to the possible detriment of understanding some interesting developmental differences. While young children are not as confused about the distinction between different object categories as Piaget supposed, the present results certainly suggest that, at least in one respect, they are also not like Western-educated adults. Young children differ by tending to broadly assign functions to objects of all kinds. Questions that therefore remain are: why is this the case, and why does the tendency become selective?

Regarding the origins of children's promiscuous teleology, one possibility is that parents are inadvertently responsible. Parents may broadly provide teleo-functional explanations to children that blur the distinction between categories. One difficulty with this account, however, is that current research indicates that parents offer children teleo-functional explanations relatively infrequently, and moreover show a bias to answer children's questions about natural phenomena with causal rather than teleological responses (Kelemen, Callanan, Casler, & Perez-Granados, 2005). An alternative possibility therefore also being explored is that, in the absence of category knowledge, children intuitively plug explanatory gaps by treating natural phenomena as though they are artifacts—a domain about which children have greater knowledge (Kelemen, 2004). Evidence in support of this "quasi-artifact" account is provided by recent results indicating that elementary school children's tendencies to assign purpose to nature are significantly correlated with beliefs that natural phenomena are intentionally designed (Kelemen & DiYanni, 2005).

This still leaves unanswered the question of why children become more selective in their assignments of function around 9 years of age. One explanation is that by this age, most Western-educated children have been engaged in formal education for several years. In consequence, children may have begun to internalize non-teleo-functional, physical-reductionist accounts of natural phenomena from explicit, repeated, pedagogical exposure. Consistent with this possibility, a recent study has found that individuals without exposure to the scientific explanations of formal Western education maintain broad preferences for teleo-functional explanations of nature into adulthood (Casler & Kelemen, 2003). Furthermore, the pattern of older children's teleo-functional responses in the current study is also consistent with the idea that formal training contributes to growing patterns of selectivity. Specifically, older children maintained teleo-functional views of living things while becoming ambivalent about non-living natural kinds. This pattern might be expected if the nature of much early science curricular material is considered. In contrast to material concerned with non-living natural phenomena, early biology curricula quite often characterize living organisms in ecological-functional terms compatible with intuitive biases to ascribe purpose to living things. It remains, however, for future research to fully explore how a scientific education interacts with children's intuitive biases over time, and also to examine the ways children's teleo-functional construal actively impacts their behavior with everyday objects.

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