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Is the bias for function-based explanations culturally universal? Children from China endorse teleological explanations of natural phenomena

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ABSTRACT

Young children in Western cultures tend to endorse teleological (function-based) explanations broadly across many domains, even when scientifically unwarranted. For instance, in contrast to Western adults, they explicitly endorse the idea that mountains were created for climbing, just like hats were created for warmth. Is this bias a product of culture or a product of universal aspects of human cognition? In two studies, we explored whether adults and children in Mainland China, a highly secular, non-Western culture, show a bias for teleological explanations. When explaining both object properties (Experiment 1) and origins (Experiment 2), we found evidence that they do. Whereas Chinese adults restricted teleological explanations to scientifically warranted cases, Chinese children endorsed them more broadly, extending them across different kinds of natural phenomena. This bias decreased with rising grade level across first, second, and fourth grades. Overall, these data provide evidence that children's bias for teleological explanations is not solely a product of Western Abrahamic cultures. Instead, it extends to other cultures, including the East Asian secular culture of modern-day China. This suggests that the bias for function-based explanations may be driven by universal aspects of human cognition.

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Introduction

> Suppose I pitched my foot against a stone, and were asked how the stone came to be there: I might possibly answer that it had lain there forever. But suppose I had found a *watch* upon the ground. . . . I should hardly think of the answer which I had before given. Yet why should not this answer serve for the watch as well as for the stone? For this reason, and for no other, viz. that, when we come to inspect the watch, we perceive that its several parts are framed and put together for a purpose.
>
> [William Paley (1802/1998, chap. 1)]

Function-based or *teleological* explanations form a fundamental part of adults' intuitive understanding of the world. We commonly use functions to explain artifacts such as tools: A bottle exists to transport water, a mug has a handle so one can hold it when it is hot, and a watch exists to tell time (e.g., Dennett, 1987; Paley, 1802/1998). Similarly, adults use functions to explain biological properties, for example, the idea that the heart exists to pump blood (e.g., Allen, Bekoff, & Lauder, 1998; Mayr, 1985; Sober, 1984). In contrast, when teleological explanations are used to explain the properties of natural objects, they are often explicitly judged as incorrect by adults and viewed as scientifically unwarranted (Kelemen, 1999a, 1999b, 1999c, 2003; Kelemen & Rosset, 2009). Thus, a mountain is not tall so that we can hike on it; the ability to allow for hiking did not cause the mountain to exist. Instead, the existence and properties of natural objects such as mountains are caused by non-teleological, physical–causal processes.

How do such complex teleological and physical explanatory frameworks develop during childhood? Like adults, children divide up the world into ontological kinds—such as artifacts, animals, and natural objects—and form intuitive mental theories of each domain (Carey, 1985, 2009; Gopnik & Meltzoff, 1997; Keil, 1989; Kelemen & Carey, 2007; Wellman & Gelman, 1992). However, young children appear to develop a general bias toward teleological explanations early in life, such that they prefer teleological explanations over physical–causal explanations across multiple domains (DiYanni & Kelemen, 2005; Kelemen, 1999a, 2003; Kelemen & DiYanni, 2005; but see Greif, Kemler Nelson, Keil, & Gutierrez, 2006, and Keil, 1992). When given the choice between function-based and physical explanations, or when asked to generate their own verbal accounts, young children in the United States and the United Kingdom endorse teleological ideas to explain not only artifacts and biological kinds but also nonliving natural phenomena (Kelemen, 1999b, 1999c, 2003; Kelemen & DiYanni, 2005). For example, children often endorse the idea that mountains exist for climbing just like hats exist for warmth.

By one account, termed *promiscuous teleology*, children's broad teleological bias is thought to arise as a product of their early understanding of intentionality, agency, and goal-directed action (Kelemen, 1999a, 1999b, 2004, 2012; see Atran, 1995, and Keil, 1992, for accounts of a more selective bias). By this account, children use teleological explanations when unwarranted due to the combination of two factors. First, children lack detailed knowledge of the physical mechanisms that account for the properties and origins of the natural world. Second, from infancy, children intuitively understand other agents' intentional behavior, including that other agents create and use objects as tools to achieve goals, and as a result privilege these types of explanations (Casler & Kelemen, 2005, 2007; Futó, Téglás, Csibra, & Gergely, 2010; Hernik & Csibra, 2015; Kelemen, 2012; Meltzoff, 1995; Phillips, Seston, & Kelemen, 2012; Stavans & Baillargeon, 2016). Thus, when confronted with questions about other aspects of the natural world, children fill their explanatory gap with what they know—their theory of animate agents and tools, which rests on functions and goals—and generate a teleological explanation.

Cross-cultural evidence: Testing the origins of teleological bias

In every culture examined, children appear to have an early-developing understanding of agents and intentional actions (e.g., Hungary: Gergely, Nádasdy, Csibra, & Biró, 1995; Japan: Kamewari, Kato, Kanda, Ishiguro, & Hiraki, 2005; Korea: Kim & Song, 2015; Germany: Sodian, Schoeppner, & Metz, 2004; United States: Brandone & Wellman, 2009; Woodward, 1998). Thus, if the promiscuous teleology account is correct that the teleological bias arises from early understanding of agents and

intentional actions, then the bias should be culturally universal. By this account, young children in every culture should, from early on, display a theory of the natural world that uses function to explain the properties and origins of inanimate natural things (such as mountains and thunderstorms), not just artifacts and animals.

Consistent with this, children in both the United States and the United Kingdom generate and endorse teleological explanations to explain nonliving natural phenomena, not just animals and artifacts (Kelemen, 1999b, 1999c, 2003; Kelemen & DiYanni, 2005). However, it remains possible that this early bias toward teleological explanations is not a product of universal aspects of cognition but rather a product of cultural and religious experience. Children's teleological bias was first documented in the United States, a majority Abrahamic (Christian, Muslim, Jewish) religious culture. Teleological explanations of nature are widespread in Abrahamic cultures and form an explicit part of religious teachings (e.g., God's creating the sun and moon "to give light to the earth" [Genesis 1:15, New American Standard Bible], plants "for food" [Genesis 1:29], and the rainbow as a "sign of the covenant" [Genesis 9:13]). In the United States, daily conversation includes a substantial amount of "God-talk" (Tickle, 1997), and adults commonly hold scientifically unwarranted teleological beliefs (e.g., that life events "happen for a reason"; Banerjee & Bloom, 2014). Although evidence of teleological bias was later found in the more secular United Kingdom (Kelemen, 2003; Kelemen & DiYanni, 2005), the United Kingdom has similarly Abrahamic religious traditions and sufficient nominal religious affiliation that it might not provide the strongest case for universality. That is, even the lower religious exposure of British children may have been sufficient to establish the bias. Indeed, British children showed a weaker bias toward teleological explanations than did children in the United States, suggesting that religious experience may play some role (Kelemen, 2003; Kelemen & DiYanni, 2005).

Is children's bias for teleological explanations a product of culture or a product of universal aspects of human cognition? Existing data cannot answer this question: Data on the development of teleological reasoning have come primarily from "WEIRD" populations—populations that are Western, educated, industrialized, rich, and democratic (Henrich, Heine, & Norenzayan, 2010)—and psychological phenomena observed in WEIRD populations might not generalize cross-culturally (e.g., Coley, 2000; Legare & Kushnir, 2015; Nielsen, Haun, Kaertner, & Legare, 2016). The development of teleological reasoning has been studied in a single non-Western culture (indigenous Quechua speakers in Peru). In this culture, participants showed a greater bias to endorse teleological explanations when scientifically unwarranted; however, Quechua culture contains high levels of explicit teleological and agentic talk regarding natural phenomena, which could account for this bias (Sanchez Tapia et al., 2016; Gelman, Mannheim, Escalante, & Sanchez Tapia, 2015). Thus, data from Quechua speakers cannot answer the question of universality; a key test is whether the teleological bias remains present even in more secular non-WEIRD populations. Recent findings from a Western sample suggest that secular culture can attenuate children's teleological tendencies: In Israel, secular Jewish children show a reduced bias for teleological explanations as compared with religious Jewish children (Diesendruck & Haber, 2009). To answer questions of universality, cross-cultural data from a range of cultures are required (Coley, 2000; Heine & Norenzayan, 2006)—and in this case data from more secular cultures provide a particularly important test case, to understand the extent to which children's teleological reasoning is shaped by culture or is cross-culturally universal.

In this study, therefore, we investigated whether children in a highly secular, non-Western, non-Abrahamic culture—China—show a bias for teleological explanations. China is an officially atheist nation, and although the extent of its atheism is controversial given the nature of certain traditional folk practices and beliefs (Adler, 2005; Stark & Liu, 2011; Yang, 2004), China is among the least explicitly theistic societies in the world (Rottman et al., 2016). In a recent poll, 82% of Chinese people claimed to lack religious belief, 75% denied the existence of supernatural agents, 84% said the afterlife does not exist, and 88% stated that they had never prayed to a supernatural power (Association of Religion Data Archives, 2007; see also WIN–Gallup International, 2012). These data contrast sharply with polls in the United States, which show (for example) that 61% feel certain that God exists (Smith, 2012). China's cultural and intellectual traditions also differ from those of Western society, with roots in the philosophies of Confucianism, Daoism, Mohism, Legalism, and Buddhism (among others). If the teleological bias is driven by some cultural feature that is specific to Western culture,

or by experience with explicit formal religious teleological content, then children in China should demonstrate an absence of any broad teleological bias.

Testing a third account: Relational versus categorical cognitive style

Data from China also provide a crucial test of a third theoretical account of children's teleological bias. This account posits that the teleological bias stems not from early developing intentional reasoning or from culture per se but rather from a certain cognitive style—the tendency to categorize items relationally (a bird goes with its environment, the sky) rather than categorically (a bird goes with another animal, e.g., a dog; ojalehto, Waxman, & Medin, 2013). China provides a highly relevant test case for this theory; whereas Americans tend to categorize items categorically, Chinese adults and children tend to categorize items relationally (Imada, Carlson, & Itakura, 2013; Ji, Zhang, & Nisbett, 2004; Kuwabara & Smith, 2012; Markus & Kitayama, 1991; Nisbett, 2003). Thus, this account (termed the relational–deictic hypothesis) makes the prediction that children in China should show a larger teleological bias and that this strong bias should continue unabated into adulthood.

The current work

In two experiments, and using two different methods, we asked whether Chinese children tend to endorse teleological explanations to explain the properties (Experiment 1) and origins (Experiment 2) of natural phenomena. We compared children's explanations across three grade levels (first, second, and fourth grades), also comparing children's explanations with those of adults. Our general question was whether Chinese children would show a broad bias for teleological explanations and, thus, would endorse these explanations not only when scientifically warranted (e.g., as explanations of artifacts) but also when scientifically unwarranted (e.g., as explanations of nonliving natural phenomena). If the promiscuous teleology account is correct, and the bias for teleological explanations is driven by universal early understanding of intentional action, then we should see an initial broad bias toward teleological explanations during early childhood, followed by a shift over development to a more selective use of teleology in explicit reasoning only in certain domains such as artifacts and biological properties. This would suggest that the bias for teleological explanations is universal and robust, developing even in the context of the more secular culture of modern-day China.

Experiment 1

In a first experiment, we asked whether Chinese children show a teleological bias when considering the properties of natural objects and animals. As in previously established methods (Kelemen, 1999c, 2003), participants were introduced to four ancient animals and objects in their habitats and asked why certain animal or object properties existed, for example, why the animal's neck was so long or why the rocks on the ground were so pointy. Participants were then presented with two alternative explanations and asked to choose the one that made more sense to them. For each question, one explanation was teleological (function based), whereas the other option was physical–mechanical (e.g., "The rocks were pointy because little bits of stuff piled on top of one another for a long time"). If children from China show a general bias to endorse teleological explanations, then children should endorse teleological explanations for natural objects' and animals' properties more often than adults, and this tendency should decrease with increasing age.

The current experiment also provided a second test of whether children have a broad bias for teleological explanations by exploring children's selectivity in the type of functional explanations that they endorse. To examine this, each physical–mechanical explanation was pitted against a teleological explanation that was one of two types: either a self-serving function (e.g., "They had smooth skin so that they could move easily through the water") or a social, other-serving function (e.g., "They had smooth skin so that other animals could swim alongside without getting cut"). Self-serving teleological explanations are considered scientifically warranted in the biological domain; many properties of

animals and plants can be seen as existing to serve a function for the organism itself, given that the properties were naturally selected because they increased evolutionary fitness by serving that function (Allen et al., 1998). In contrast, social teleological explanations are considered scientifically unwarranted in the biological domain (with the exception of properties that increase the fitness of kin; Darwin, 1859; Dawkins, 1976; Futuyma, 1998). Both kinds of teleological explanations are considered scientifically unwarranted in the domain of nonliving natural objects.

If children from China show a general bias to endorse teleological explanations, then younger participants should endorse both social and self-serving teleological explanations for animals' properties in spite of the fact that only the self-serving explanations are of a scientifically warranted type. In addition, younger children should endorse teleological explanations not only for animals' properties but also for the properties of nonliving natural objects. Older children and adults should become more selective with age, endorsing self-serving teleological explanations more often than social teleological explanations for animals' properties and increasingly rejecting both types of teleological explanations for the properties of natural objects. In contrast, if the teleological bias is solely a product of Western culture, then children and adults in China should show selective use of teleology, endorsing only self-serving teleological explanations of animals' properties. Lastly, if the teleological bias is a product of relational–deictic reasoning, then Chinese children and adults both should show a strong and general bias to endorse teleological explanations across all domains.

Method

Participants

The participants were 48 children and 16 adults from China. Adults were university undergraduates in Beijing (8 male; mean age = 21 years 6.9 months, *SD* = 15.5 months). Children were from an elementary school in Baoding, a city 93 miles southwest of Beijing with a population of more than 10 million over 710 square miles. Thus, consistent with previous U.S. and U.K. samples (Kelemen, 1999c, 2003; Kelemen & DiYanni, 2005), children were drawn from an urban public school, not a high-SES (socioeconomic status) university town population. They were 16 first graders (8 male; mean age = 6 years, 9.8 months, *SD* = 10.1 months), 16 second graders (8 male; mean age = 8 years, 5.3 months, *SD* = 7.5 months), and 16 fourth graders (8 male; mean age = 9 years, 4.4 months, *SD* = 10.3 months).

Design and procedure

Children were tested individually in a quiet room with an experimenter at school; adults completed a pencil-and-paper version of the same task. All linguistic stimuli were translated into Mandarin Chinese from those used to test children in the United States in previous work (see "Translation procedures" section below). As in previous work (Kelemen, 1999c, Experiment 2; 2003, Experiment 1), participants were sequentially shown each of four sets of two pictures. Each set consisted of an image of a novel animal species, showing several individuals of the species, and an image of an object found in its habitat (an aquatic reptile and a pointy rock, a large mammal and a still pond, a terrestrial bird and a grainy sand dune, or a small mammal and a green stone). Participants were told that the animal was an ancient animal and that the object was found "during that same time." For each of the four picture sets, participants were asked two "why" questions about biological properties of the animal kind (e.g., "Why do you think [species name] had such long necks?") and one "why" question about a property of the nonliving natural object kind (e.g., "Why do you think the rocks were so pointy?"), for a total of 12 questions per participant (8 animal and 4 natural object).[1]

[1] To maintain methodological consistency with previous work in the United States (Kelemen, 1999c) and the United Kingdom (Kelemen, 2003), we included two biological property questions for each set of pictures. The two biological property questions differ in the specific phrasing of the teleological explanations. This phrasing difference has been shown not to matter; in previous work, participants' endorsement of the two types of biological property questions did not differ (see Kelemen, 1999c, pp. 1446–1447).

Immediately after each question, the experimenter offered two possible answers and participants were asked to select the answer that "made the most sense" to them as an explanation of the animal's or object's properties. One answer choice was always a physical–mechanical explanation (e.g., "The rocks were pointy because bits of stuff piled up on top of one another for a long time"). The other choice was a teleological (function-based) explanation of one of two types: self-serving functions (e.g., "The rocks were pointy so that animals wouldn't sit on them and smash them") and social or other-serving functions (e.g., "The rocks were pointy so that animals could scratch on them when they got itchy"). Each function type was used for half of the picture sets. Thus, for any particular question, all participants heard the same physical explanation; half heard this paired with the self-serving teleological explanation, whereas the other half heard the social teleological explanation.

To match the procedure previously used to test children in the United States and the United Kingdom, the same randomized orders were presented to participants as had been used with participants in past work (Kelemen, 1999c, 2003; Casler & Kelemen, 2008). For each participant, the teleological answer choice was presented first on half of the questions (randomly selected); the order of the picture sets was pseudorandomized so that half of the participants within each grade level saw two of the four picture sets first and half saw the other two picture sets first. Also in line with previous work, participants were provided with an introduction to the task that promoted a physical explanatory framework to ensure a conservative measure of children's level of teleological bias (Kelemen, 1999c, Experiment 2; 2003, Experiment 1). In particular, participants viewed drawings of three different kinds of clouds and heard a physical–causal explanation of "how scientists think clouds form and why they think they are in the sky." They were then encouraged to "think like scientists" during the task. See Supplementary Material for details and stimuli in both English and Mandarin.

Translation procedures

All linguistic stimuli were translated into Mandarin Chinese by the joint translation work of two bilingual Chinese–English speakers and one native English speaker. The stimuli were first translated into Mandarin Chinese by one bilingual Chinese–English speaker; this translation was back-translated into English by a second bilingual Chinese–English speaker and compared with the original English by the native English speaker and the second bilingual individual. Discrepancies were marked, and alternative translations were suggested. The original translator reviewed these comments and completed a new version. This procedure of back-translation and editing was repeated a total of four times until all agreed that the Chinese translations of stimuli were appropriate and equivalent to the original English text. The quality of these translations was then checked again empirically with a larger sample of Chinese-speaking adults. Findings from this translation quality experiment are detailed in the Results section below (see Supplementary Material for methodological details and full stimuli in both English and Mandarin).

Results

Translation quality data

To determine whether any trials contained an answer choice sentence of poor linguistic quality or contained answer choices that differed in linguistic quality, we presented a new set of adult fluent Chinese speakers ($N = 19$) with each of the answer choice sentence pairs and asked them to judge linguistic quality. For each pair of sentences, participants were asked to rate the quality of the language in each individual sentence and to compare the quality of the two sentences to judge whether one sounded more natural than the other (see Supplementary Material for details of method).

We accounted for translation quality in our analyses in two ways. First, we excluded any trial with an answer choice sentence rated as "bad Chinese." This resulted in the exclusion of 3 of 24 trials (see Supplementary Material). Second, to account for differences in translation quality across every trial, we performed a repeated-measures logistic regression on all data with translation quality as a predictive factor (as well as all conditions and interactions of interest). This allowed us to examine the effects of our variables of interest independent of translation quality. Findings from this analysis were identical to those of the parametric analyses presented below (see Supplementary Material).

Rate of selecting teleological explanations

To examine effects of grade level (1, 2, 4, or adult), property type (animal or natural object), and function type (social or self-serving) on participants' tendency to select teleological explanations, we performed a 4 × 2 × 2 mixed analysis of variance (ANOVA) with the proportion of trials on which participants selected teleological explanations as the dependent measure (see Fig. 1 and Supp. Table 1).

As predicted, we found a main effect of grade level, such that participants were less likely to choose teleological explanations with increasing grade level, $F(3, 60) = 5.51$, $p = .01$, $\eta_p^2 = .22$, and a main effect of property type, such that participants were more likely to choose teleological explanations for animals' properties than for natural objects' properties, $F(3, 60) = 6.10$, $p = .02$, $\eta_p^2 = .09$. Finally, we found a main effect of function type, such that participants were more likely to choose teleological explanations when they were self-serving than when they were social teleological explanations, $F(3, 60) = 13.12$, $p < .001$, $\eta_p^2 = .18$—consistent with the idea that self-serving explanations are sometimes scientifically warranted (for animals' properties), whereas the other-serving explanations are not scientifically warranted in either domain.

We also found two-way interactions of grade with property type, property type with function type, and grade with function type. No three-way interaction was revealed. The interaction of grade with property type occurred because adults, fourth graders, and second graders chose teleological explanations more often for animals' properties than for natural objects' properties, but first graders did not, $F(3, 60) = 3.20$, $p = .03$, $\eta_p^2 = .14$. The interaction of property type with function type occurred because when explaining animals' properties participants chose self-serving teleological explanations more often than social teleological explanations, but they did not do so when explaining the properties of natural objects, $F(3, 60) = 9.12$, $p < .01$, $\eta_p^2 = .13$. The interaction of grade with function type occurred because participants in higher grade levels chose self-serving teleological explanations more often than social teleological explanations, whereas participants in lower grades did not, $F(3, 60) = 3.32$, $p = .03$, $\eta_p^2 = .14$.

If young children show a general bias to endorse teleological explanations regardless of their specific content, then when explaining animals' properties younger participants should endorse both types of teleological explanations—social as well as self-serving. In contrast, older children and adults should become more selective with age—endorsing self-serving teleological explanations (which are often scientifically warranted) more often than social teleological explanations. To test this prediction, we examined the animal properties trials only, performing a 4 (Grade) × 2 (Function Type) mixed ANOVA with the proportion of trials on which participants selected teleological explanations as the dependent measure. As predicted, we found a significant interaction of grade with function type, $F(3, 60) = 6.99$, $p < .001$, $\eta_p^2 = .26$; main effects: function type, $F(3, 60) = 40.55$, $p < .001$, $\eta_p^2 = .40$; grade, $F(3, 60) = 2.68$, $p = .055$, $\eta_p^2 = .12$. Thus, selectivity increased with increasing grade; adults endorsed only self-serving teleological explanations for animals' properties, and as grade level decreased children more broadly endorsed both social and self-serving teleological explanations for animals' properties (see Fig. 1, left side).

Second, if young children have a broad bias for teleological explanations, then when explaining natural objects' properties younger participants should endorse both social and self-serving teleological explanations. In contrast, older children and adults should come to reject both of these types of teleological statements as explanations for natural objects' properties (because, e.g., rocks are not pointy for their own benefit or for the benefit of others but only as the result of a physical process). To test this prediction, we examined the natural objects' properties trials only, performing a 4 (Grade) × 2 (Function Type) mixed ANOVA with the proportion of trials on which participants selected teleological explanations as the dependent measure (see Fig. 1 and Supp. Table 1). As predicted, we found no interaction of grade with function type and a main effect of grade, $F(3, 60) = 0.16$, $p = .92$, $\eta_p^2 = .01$; main effects: grade, $F(3, 60) = 5.73$, $p = .002$, $\eta_p^2 = .22$; function type, $F(3, 60) = 0.00$, $p = 1.00$, $\eta_p^2 = .00$. Thus, younger children were equally likely to endorse both types of teleological explanation for natural objects, and participants came to reject both kinds of teleological explanations for natural kinds with increasing grade level.

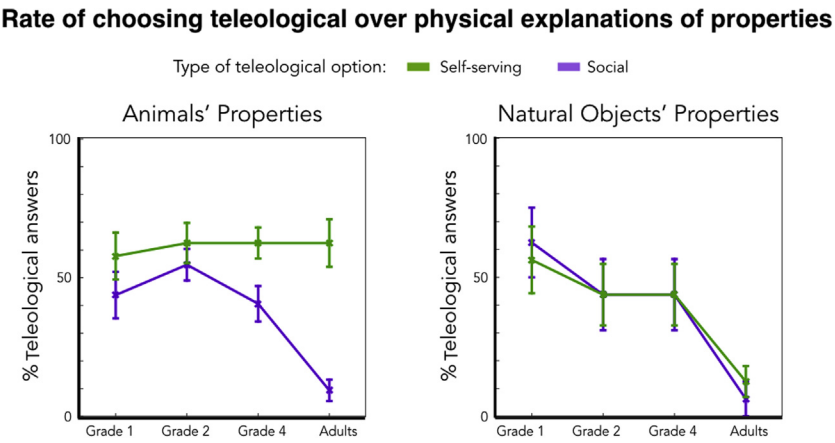

Fig. 1. Mean percentages of trials on which participants selected teleological explanations over physical explanations of properties for each grade, property type, and function type. Trials identified as poor linguistic quality are excluded (3/24 trials). Error bars are standard errors of the means.

Individual differences in teleological bias

Younger children endorsed scientifically unwarranted teleological explanations far more often than adults; however, no age group endorsed teleological explanations at a rate much higher than 50%, even in cases where they could be considered scientifically warranted. Did children in China find teleological and physical explanations equally plausible? Were they simply unsure and guessing based on minimal information? Or was this pattern due to individual differences—that is, whereas some participants within a grade tended to select teleological explanations, others tended to select physical explanations?

To test whether participants within a grade level significantly differed from one another in the extent of their preference for teleological explanations, we asked whether the amount of variance within each grade level was higher than we would expect if all participants had the same underlying level of preference for teleological explanations (e.g., if all were choosing with a 50/50 chance based on little information). We used Monte Carlo methods to generate the distribution of variances expected under the null hypothesis (i.e., the hypothesis that all participants from each age group had the same level of preference and, thus, came from the same distribution). We then asked whether the observed variance was higher than expected if the participants all came from this null distribution (see Supplementary Material for methodological details).

We found that for all grade levels of children, and also for adults, the level of variance across participants was higher than we would expect if there were no individual differences: first graders, observed variance = 8.13, expected variance under the null hypothesis = 2.47, $p < .0001$; second graders, observed variance = 6.92, expected variance = 2.43, $p < .0001$; fourth graders, observed variance = 5.53, expected variance = 2.50, $p < .01$; adults, observed variance = 3.76, expected variance = 2.16, $p = .03$; all two-tailed. Thus, even for group-level means near 50%, participants were not simply guessing by flipping a 50/50 coin. Instead, participants differed from one another in the extent of their preference for teleological explanations; some participants within each grade level had a stronger bias for teleological explanations than others in that grade level.

Discussion

Our results provide two forms of evidence that children in China have a broad bias for teleological explanations during early childhood, followed by a developmental shift to a more selective use of teleological explanations in later explicit reasoning.

First, we find that at the youngest grade level tested, Chinese children endorsed teleological explanations equally often in a domain where these explanations are not scientifically warranted (nonliving natural objects' properties) as in a domain where these explanations are often scientifically warranted (animals' properties). In contrast, adults, fourth graders, and second graders chose teleological explanations more often for animals' properties than for natural objects' properties. With increasing grade level, participants became more selective in endorsing teleological explanations only in the scientifically warranted domain.

Second, we find evidence that young children have a general tendency to endorse teleological explanations regardless of their specific content. Despite individual differences, participants in younger grades endorsed both social and self-serving teleological explanations for animals' properties—in spite of the fact that only the self-serving explanations are of a scientifically warranted type. Older children and adults again became more selective with age, endorsing self-serving teleological explanations more often than social teleological explanations of animals' properties.

These data weigh against the idea that the teleological bias is solely a product of Western culture and suggest that a broad bias for teleological explanations during early childhood is evident across disparate cultures. These data also weigh against the relational–deictic reasoning account, which predicts that Chinese adults should maintain a strong and general bias for teleological explanations due to their tendency to categorize items relationally rather than categorically (ojalehto et al., 2013). However, Chinese adults were less teleological than Chinese children and were highly selective, endorsing teleological explanations only when they were both in a scientifically warranted domain (animals' properties) and of a scientifically warranted type (self-serving). This suggests that teleological explanatory tendencies are not a product of relational–deictic reasoning.

Experiment 2

In Experiment 1, we found evidence that children in China broadly endorse teleological (function-based) explanations of *properties* of the natural world. In a second experiment, we asked whether children in China also have a bias to explain the *origins* of the natural world in teleological terms. Western children in the United Kingdom have shown such a bias, endorsing teleological explanations of the origins of not only artifacts but also natural objects such as mountains and animals (Kelemen & DiYanni, 2005). Does this pattern generalize to the secular, non-WEIRD culture of contemporary China?

All participants took part in two tasks to explore their reasoning about the origins of four kinds of phenomena: animals, natural objects, natural events, and artifacts. In a first task, participants were asked an open-ended question about the origins of each item (e.g., why did the first ever thunderstorm occur?) and were asked to generate their own explanations. These open-ended answers were coded into categories, including whether or not the explanation was teleological. Similar methods have been used with children in China to examine biological reasoning (Legare, Zhu, & Wellman, 2013) and have been shown to accord with other measures such as children's predictions (Legare, Wellman, & Gelman, 2009; Legare et al., 2013). In a second task, participants were asked about the origins of each item and were asked to choose between two potential explanations (a method similar to Experiment 1). One of the two answer choices was always a physical explanation (e.g., "The first ever thunderstorm occurred because some cold and warm air all rubbed together in the clouds"), whereas the other answer choice was always a scientifically unwarranted social (other-serving) teleological explanation (e.g., "The first ever thunderstorm occurred to give the earth water so everything would grow").[2]

If the promiscuous teleology account is correct that young children universally have a general bias for teleological explanations, then children should generate and endorse teleological explanations even when scientifically unwarranted; that is, when explaining why natural phenomena such as birds, rivers, and thunderstorms first came to exist. When explaining the origins of artifacts such as boats, both adults and children should endorse teleological explanations; these explanations are

[2] These two tasks map onto the first two parts of the method of Kelemen and DiYanni (2005). The final task of that study is not included here because a suitably agent-indeterminate translation of the English question "Did someone make the first ever [X]?" was not found in Mandarin. In particular, the Chinese word for "someone" refers only to persons, not to other agents (e.g., it does not include God or spirits), whereas the English word "someone" is agent indeterminate (and, thus, does include God and spirits).

scientifically warranted because artifacts are observably created for a function by a human agent. With increasing grade, older children and adults should come to use teleological explanations more selectively, reserving them only for the artifact domain.

In contrast, if the bias for teleological explanations is driven by some unique aspect of Western culture or religion, then younger Chinese children and older Chinese children and adults should show similarly low tendencies to generate and endorse teleological explanations of natural phenomena. Finally, if the bias for teleological explanations is caused by differences in cognitive style (relational vs. categorical reasoning; ojalehto et al., 2013), then children at all ages in China should show a broad teleological bias, with this bias persisting in explicit reasoning even into adulthood.

Teleological explanations appear to be conceptually related to intentional explanations of origins; in previous work, individuals who endorsed teleological explanations of the origins of nature also tended to endorse the notion that natural phenomena are caused by an animate agent such as God or Gaia (Kelemen & DiYanni, 2005; Kelemen & Rosset, 2009; Kelemen, Rottman, & Seston, 2013). These two ideas fit together into a coherent teleo-agentic explanatory framework: Something may be created by an agent in order to serve a function. This explanatory framework contrasts with alternative physical–mechanistic explanatory frameworks, for example, that geological features were caused by sediment accumulating or eroding and that certain types of animals were naturally selected by having more offspring than others (evolution). In investigating explanations of origins, we aimed to measure participants' tendency to appeal to this overarching teleo-agentic conceptual framework as well as their tendency to appeal to teleology alone.

Method

Participants

Participants were 48 elementary school children in Baoding and 16 adults in Beijing. Most children had not participated in Experiment 1 (10 individuals had: 4 fourth graders, 3 second graders, and 3 first graders). Adults were the same individuals as in Experiment 1. There were 16 first graders (8 male; mean age = 6 years 8.4 months, *SD* = 8.2 months), 16 second graders (9 male; mean age = 7 years 11.3 months, *SD* = 11.5 months), and 16 fourth graders (8 male; mean age = 9 years 10.7 months, *SD* = 6.5 months).

Design and procedure

Children were tested individually in a quiet room with an experimenter at school; adults completed a pencil-and-paper version of both tasks. All stimuli were translated into Mandarin Chinese from those used to test children in the United Kingdom (Kelemen & DiYanni, 2005) using the same methods and translators as for Experiment 1. Participants were told that the experimenter was going to ask them their beliefs about all kinds of different things. As in Kelemen and DiYanni (2005), they were assured at length that it was okay to give their best guess, even if they were unsure, before proceeding to the main task (see Supplementary Material). Participants were then shown each of eight color photographs in turn and asked about the origins of each one: two animals (bird and monkey), two nonliving natural objects (mountain and river), two natural events (thunderstorm and flood), and two artifacts (hat and boat).

Each participant took part in two tasks: one open-ended questions task (in which participants generated their own answers) and one closed-ended questions task (in which answer choices were provided). To avoid suggesting possible responses for the open-ended task (via the options in the closed-ended questions), the open-ended task was presented first. To match the procedure used to test children in the United Kingdom, items were kept in the same order as in previous work (thunderstorm, bird, river, monkey, mountain, flood, boat, hat; Kelemen & DiYanni, 2005). Answer choice order was counterbalanced across participants, with the teleological answer choice presented first on half of questions within each participant.

Open-ended origins questions. In the first task, for each test item the experimenter showed children the relevant picture, labeled the item, and verified that children were familiar with the item. Then, the experimenter asked, "Here's the question: Why did the first ever [X] exist? Why did it occur?"

Participants then generated their own verbal explanations for the origins of each item. If children hesitated, replied that they did not know, or provided nonanswers (e.g., descriptions of the pictures, irrelevant comments), the question was repeated (e.g., "Okay, but why did the first *ever* bird come to exist?") and children were reminded that they should just give their best guess. In cases where responses were unclear, children were asked to clarify (e.g., "Can you say that again for me? I'm not sure I understand"). If children continued to say "I don't know" or to provide an unclear answer, the experimenter moved on to the next item.

Closed-ended origins questions. In the second task, participants were told that they would hear the ideas of two other people and should pick which one made the most sense to them. Participants were then asked about the origins of each item again and asked to choose between two explanations of its origins: a physical explanation (e.g., "The first ever thunderstorm occurred because some cold and warm air all rubbed together in the clouds") and a teleological explanation (e.g., "The first ever thunderstorm occurred to give the earth water so everything would grow"). All teleological explanations described a function that was other-serving or social in that the beneficiary was external to the object itself.

Analysis of answers to open-ended origins questions. Children's open-ended answers were transcribed from video recordings of the experimental sessions by a native Mandarin Chinese speaker. Transcriptions (and adults' written answers) were then translated into English by a team of three bilingual Chinese–English speakers. First, translators worked in pairs to determine English translations. A third translator then independently checked these translations and marked any disagreements. Translation disagreements were resolved by discussion among all translators.

The translated answers were then coded into descriptive categories. In particular, we coded whether participants had explained the items' origins by appealing in a teleological way to the items' functions or purposes ("for function"), to an animate intentional agent ("by agent") and/or by appealing to a physical process ("physical"). In addition, we created a category that included all answers that appealed to a teleo-agentic explanatory framework by including any answer that had appealed to either functions or agents. We also coded whether participants had provided some other uncodeable, irrelevant, or ambiguous response such as stating only that they did not know or simply repeating the prompt or describing the picture (e.g., question: "Why did the first thunderstorm exist?"; answer: "Thunderstorm is thundering"). Answers received multiple codes when applicable. Two coders coded 100% of the answers. After coding all answers, initial disagreements (<10% of answers) were resolved through discussion.

Results

Rate of generating each type of explanation to open-ended questions

The average rates of providing teleological, agentic, and physical explanations are shown in Table 1. In addition to these responses, children produced uncodeable responses on a notable proportion of trials; that is, they frequently failed to answer, said they did not know, or produced irrelevant responses such as repeating the prompt. These uncodeable responses were included in analyses as the absence of teleological, agentic, or physical explanation. Children in lower grade levels produced uncodeable responses most frequently: first graders, $M = .39$, $SD = .42$; second graders, $M = .23$, $SD = .38$; fourth graders, $M = .18$, $SD = .30$; adults, $M = .03$, $SD = .12$. The number of uncodeable responses decreased over the course of the task, that is, once children had been repeatedly reassured that it was fine to guess: logistic regression, $b = -0.31$, $SE = 0.05$, $p < .0001$. This suggests that uncodeable responses may have been given when participants were uncertain (see Discussion below). Table 1 breaks down the proportion of answers falling into each category when considering uncodeable as well as codeable responses.

Rate of generating teleological explanations to open-ended origins questions

To examine effects of grade level (1, 2, 4, or adult) and item kind (natural events, nonliving natural objects, animals, or artifacts) on participants' rate of providing teleological explanations, we

Table 1
Mean percentages of trials on which teleological, agentic, and physical explanations were provided for the origins of each kind of item (animals, natural objects, natural events, and artifacts). Standard deviations are in parentheses.

(A) Mean percentages, trials with codeable answers only

	Animals			Natural objects		
	Teleological	Agent	Physical	Teleological	Agent	Physical
Grade 1	40 (55)	40 (55)	40 (55)	39 (49)	4 (13)	64 (46)
Grade 2	33 (44)	21 (40)	58 (47)	42 (51)	8 (19)	58 (42)
Grade 4	12 (30)	46 (48)	58 (49)	17 (31)	17 (31)	77 (37)
Adult	28 (41)	0 (0)	96 (13)	16 (35)	0 (0)	100 (0)
	Natural events			Artifacts		
	Teleological	Agent	Physical	Teleological	Agent	Physical
Grade 1	12 (30)	4 (14)	92 (28)	40 (47)	67 (45)	0 (0)
Grade 2	21 (43)	4 (13)	75 (43)	44 (48)	78 (41)	0 (0)
Grade 4	13 (29)	19 (40)	88 (29)	50 (48)	84 (35)	0 (0)
Adult	13 (29)	0 (0)	97 (13)	94 (17)	50 (48)	0 (0)

(B) Mean percentages, all trials (including uncodeable answers)

	Animals				Natural objects			
	Teleological	Agent	Physical	Uncodeable	Teleological	Agent	Physical	Uncodeable
Grade 1	6 (17)	9 (27)	6 (17)	81 (31)	28 (41)	31 (13)	44 (40)	28 (36)
Grade 2	19 (31)	16 (35)	41 (46)	34 (44)	25 (41)	6 (17)	44 (44)	31 (44)
Grade 4	6 (17)	25 (32)	34 (40)	41 (38)	16 (30)	16 (30)	69 (40)	9 (27)
Adult	28 (41)	0 (0)	94 (17)	3 (13)	16 (35)	0 (0)	97 (13)	3 (13)
	Natural events				Artifacts			
	Teleological	Agent	Physical	Uncodeable	Teleological	Agent	Physical	Uncodeable
Grade 1	9 (27)	3 (13)	56 (40)	37 (39)	38 (47)	59 (46)	0 (0)	9 (27)
Grade 2	16 (35)	3 (13)	53 (43)	28 (36)	44 (48)	78 (41)	0 (0)	0 (0)
Grade 4	9 (20)	13 (29)	72 (31)	19 (25)	47 (46)	81 (36)	0 (0)	3 (13)
Adult	9 (20)	0 (0)	91 (20)	6 (17)	94 (17)	50 (48)	0 (0)	0 (0)

Note: Percentages may add to greater than 100 due to multiple codes applying to some trials (i.e., responses with multiple explanations).

performed a 4×4 mixed ANOVA with item kind as a repeated measure and the proportion of trials on which participants produced teleological explanations as the dependent measure (see Table 1).

We found a main effect of item kind: Participants were more likely to provide teleological explanations of artifacts than other types of items, $F(3, 60) = 37.96$, $p < .0001$, $\eta_p^2 = .39$. As predicted, we also found an interaction between item kind and grade level, $F(9, 60) = 4.43$, $p < .0001$, $\eta_p^2 = .18$; participants' grade level affected their likelihood of generating teleological explanations differently for different kinds of items. Both adults and children at all grade levels generated teleological explanations for artifacts at a high rate, with adults generating teleological explanations for artifacts most often of any grade level (see Table 1). For natural objects, in contrast, first graders generated teleological explanations the most frequently of any grade level, and the rate consistently declined with increasing grade, with adults providing teleological explanations the least frequently. For animals and natural events, the change in rate of teleological explanations with age was less consistent; however, for these domains children often generated agent-based explanations, which may reveal the same teleo-agentic conceptual framework as teleological explanations (Kelemen & DiYanni, 2005). To take this teleo-agentic framework into account, we next examined rates of generating any teleo-agentic explanation versus a physical explanation.

Rate of generating teleo-agentic explanations to open-ended origins questions

To examine participants' tendency to use a teleo-agentic framework versus a physicalist framework, we calculated the percentage of trials on which participants provided teleo-agentic explanations

(appealing to agents, functions, or both) or physical explanations (Table 1). To examine effects of grade level (1, 2, 4, or adult), explanation type (teleo-agentic or physical), and item kind (natural events, nonliving natural objects, animals, or artifacts) on participants' rate of providing such explanations, we performed a $4 \times 2 \times 4$ mixed ANOVA with item kind and explanation type as repeated measures and the proportion of trials on which participants produced each type of explanation as the dependent measure.

We found a main effect of grade level, such that older participants were less likely to provide teleo-agentic explanations and more likely to provide physical explanations, $F(3, 60) = 10.27$, $p < .0001$, $\eta_p^2 = .34$, as well as a main effect of item kind, $F(3, 180) = 9.71$, $p < .0001$, $\eta_p^2 = .14$. There was an interaction between grade and explanation type, $F(3, 60) = 5.59$, $p < .01$, $\eta_p^2 = .22$, such that participants in different grades differed in their explanation types. There was also an interaction between grade and item kind, $F(9, 180) = 5.23$, $p < .0001$, $\eta_p^2 = .21$, and an interaction between explanation type and item kind with a large effect size; participants generated different types of explanations for different item kinds, $F(3, 180) = 157.97$, $p < .0001$, $\eta_p^2 = .73$.

As predicted, there was also a three-way interaction among grade, item kind, and explanation type, $F(9, 180) = 2.63$, $p < .01$, $\eta_p^2 = .12$. Thus, depending on the item kind, grade and explanation type interacted differently. In particular, for artifacts, participants at all grade levels provided teleo-agentic explanations on all codeable trials (see Table 1) and never provided physical explanations for artifacts' origins. In contrast, when explaining natural objects, there was a consistent decline in teleo-agentic explanations with increasing grade. When explaining animals, there was a similar decline of teleo-agentic explanations with increasing grade—although in this category the higher rate of uncodeable responses for lower grade-level children than other participants meant that this pattern was only apparent when considering the proportion of codeable responses (see Table 1). Lastly, for natural events, the change in rate of teleological explanations with age was less consistent; first graders provided teleo-agentic explanations at approximately the same level as did adults, and physical explanations were common across all grade levels. This finding mirrors that of previous work: Children in the United Kingdom also provided more physical than teleo-agentic explanations of natural events in this task (Kelemen & DiYanni, 2005), perhaps due to experience with and learned knowledge of the physical origins of the specific items tested in those domains.

Closed-ended origins questions, translation quality data

As in Experiment 1, a separate set of fluent adult Chinese speakers ($N = 19$) was asked to judge the linguistic quality of each of the answer choice sentence pairs from the closed-ended question task. We accounted for translation quality in our analyses by excluding trials with an answer choice sentence rated as "bad Chinese," as in Experiment 1. This resulted in the exclusion of 1 of 8 trials from Part 2 (from the animals category; see Supplementary Material).[3]

Rate of selecting teleological explanations of origins to closed-ended origins questions

To examine effects of grade level (1, 2, 4, or adult) and item kind (natural events, nonliving natural objects, animals, or artifacts) on participants' tendency to select teleological explanations, we performed a 4×4 mixed ANOVA with the proportion of trials on which participants selected teleological explanations as the dependent measure (see Fig. 2 and Supp. Table 2).

We found a main effect of grade level, such that participants were less likely to choose teleological explanations with increasing grade level, $F(3, 60) = 9.54$, $p < .0001$, $\eta_p^2 = .32$. We also found a main effect of item kind, such that participants were more likely to choose teleological explanations for artifacts than for natural events, natural objects, or animals, $F(3, 180) = 18.21$, $p < .0001$, $\eta_p^2 = .23$. As predicted, there was an interaction of grade with item kind, $F(9, 180) = 5.74$, $p < .0001$, $\eta_p^2 = .22$. This occurred because whereas adults exclusively chose teleological explanations for artifacts and rarely

[3] We also attempted repeated-measures logistic regression on all data with translation quality as an additional predictive factor, as in Experiment 1. However, this model could not be fit to these data, likely due to the smaller number of data points than in Experiment 1.

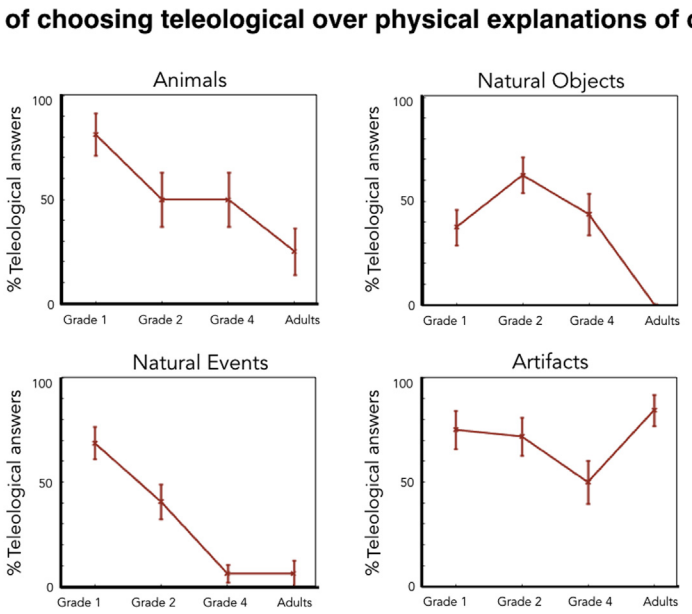

Fig. 2. Mean percentages of trials on which participants selected teleological explanations over physical explanations for each kind of item and each grade level. One trial was identified as poor linguistic quality (1/8 trials) and is excluded. Error bars are standard errors of the means.

endorsed teleological explanations for other kinds [artifacts vs. animals, $t(15) = 4.54$, $p < .001$; artifacts vs. natural objects, $t(15) = 11.21$, $p < .0001$; artifacts vs. natural events, $t(15) = 8.59$, $p < .0001$; all two-tailed t tests], younger children did not show this specificity. In particular, first graders chose teleological explanations at a statistically equivalent rate for artifacts as for animals or natural events [artifacts vs. animals: $t(15) = -0.49$, $p = .63$; artifacts vs. natural events, $t(15) = 0.70$, $p = .50$; both two-tailed t tests], and second and fourth graders chose teleological explanations at an equivalent rate for artifacts as for natural objects or animals [second graders: artifacts vs. natural objects, $t(15) = 0.82$, $p = .42$; artifacts vs. animals, $t(15) = 1.80$, $p = .09$; fourth graders, artifacts vs. natural objects, $t(15) = 0.62$, $p = .54$; artifacts vs. animals, $t(15) = 0.00$, $p = 1.00$]. In addition, rates of choosing teleological explanations decreased with increasing grade level in the domains of animals, $F(3, 63) = 3.79$, $p = .015$, $\eta^2 = .16$, natural objects, $F(3, 63) = 11.12$, $p < .0001$, $\eta^2 = .36$, and natural events, $F(3, 63) = 19.84$, $p < .0001$, $\eta^2 = .50$, but did not reliably decline with grade level in the domain of artifacts, $F(3, 63) = 2.59$, $p = .06$, $\eta^2 = .11$ (see Fig. 2).

Individual differences in teleological bias

As in Experiment 1, we analyzed the variance within each grade level to look for evidence of individual differences in preference for teleological explanation. Using the same Monte Carlo simulation method as in Experiment 1, we tested whether the amount of variance within each grade level was higher than we would expect if all participants had the same underlying level of preference for teleological explanations. We found that the answers of first graders, fourth graders, and adults showed a variance no higher than expected by chance: first graders, observed variance = 1.72, expected variance under the null hypothesis = 1.64, $p = .40$; fourth graders, observed variance = 2.40, expected variance = 1.60, $p = .08$; adults: observed variance = 0.86, expected variance = 1.45, $p = .89$; all two-tailed. Only second graders' variance was higher than expected by chance (observed variance = 3.20, expected variance = 1.71, $p = .01$, two-tailed). Thus, some children at this grade level still had the stronger teleological bias of younger children, whereas others were more adult-like in their explanations (see Discussion below).

Discussion

Our results provide evidence that when explaining the origins of natural phenomena, younger Chinese children show a broad bias for teleological explanations followed by a shift to more selective use of teleological explanations during later childhood and adulthood. Across two methods, children endorsed scientifically unwarranted teleological explanations of natural phenomena at a rate higher than adults, generating teleological explanations in open-ended answers and choosing them in closed-ended answers. This teleological tendency declined over childhood in both tasks and became increasingly specific with increasing grade level.

By investigating participants' open-ended explanations, we were able to examine their tendency to appeal to an overarching teleo-agentic conceptual framework as well as their tendency to appeal to teleology alone. We found that participants' tendency to appeal to a teleo-agentic explanatory framework followed a similar developmental trajectory to that of teleological explanations in other tasks: Children used teleo-agentic explanations most broadly at the youngest grade level tested and more selectively with increasing grade level. For artifacts, participants at all grade levels provided teleo-agentic explanations on all codeable trials and never provided physical explanations. In contrast, for natural objects and animals, participants' rate of teleo-agentic explanations declined with increasing grade.

As in Experiment 1, these data again weigh against the relational–deictic reasoning account (ojalehto et al., 2013), which predicts that Chinese adults should show a general bias for teleological explanations even when scientifically unwarranted and that Chinese children should not differ from adults. In contrast to these predictions, and in line with Experiment 1, we found that (a) Chinese adults did not show a general bias but selectively appealed to teleological explanation when scientifically warranted and (b) Chinese children showed a much stronger overall bias for teleological explanation than Chinese adults. This pattern is not consistent with the proposal that the bias toward teleological explanations is a product of relational–deictic reasoning. These data instead provide converging evidence that the teleological bias is not solely a product of Western culture or cognitive style, but rather due to universal aspects of culture or cognition.

Individual differences in teleological bias

As in Experiment 1, we analyzed the variance within each grade level to look for evidence of individual differences in preference for teleological explanations. We found evidence that only second graders differ from one another in the extent of their preference for teleological explanations of origins; in contrast, the answers of first graders, fourth graders, and adults showed no evidence of individual differences. This suggests that in second grade a developmental transition may be occurring, from the early childhood broad bias for teleological explanations of origins to a more adult-like specificity in explicit endorsement of teleological explanations. Thus, some children at the second-grade level may retain the stronger teleological bias of younger children, whereas others are more adult-like in their explanations.

Effects of uncertainty on open-ended explanations

In the open-ended task of Experiment 2, children at lower grade levels more often gave uncodeable answers (e.g., repeating the prompt, saying they did not know, indeterminate responding) than did participants at higher grade levels. These uncodeable answers likely reflect response uncertainty rather than a lack of understanding of the task; in Chinese schools, there is a long tradition of emphasis on didactic teacher- and examination-oriented learning (*yingshi jiaoyu*), resulting in a focus on content mastery that discourages inaccurate responding even from early ages (e.g., Dello-Iacovo, 2009; Gao, 1998; Marton, 2006; Zhang & Fan, 2014). In consequence, the presence of a teacher-like experimenter asking questions in a school setting likely played a role in children's behavior: Children may have been reluctant to answer when they were uncertain of the academic correctness of their own explanations. Consistent with this, experimenters frequently noted that children appeared nervous during experimental sessions (e.g., stating "Are you nervous? Don't be nervous, we're just playing a game"), and children gave uncodeable answers less often later in the task once they had received repeated reassurances that it was fine to guess.

This dynamic warrants additional confidence in the data from trials with codeable answers: Given the likely aversion to offering low-confidence answers, when children did generate teleological or physical explanations in the open-ended task, they probably strongly endorsed them. Such high-confidence answers are more likely to be accurate and reliable (Macmillan & Creelman, 2005; Wixted, Mickes, Dunn, Clark, & Wells, 2016). A further consequence, however, is that the open-ended question task may have underestimated children's teleological bias. By the promiscuous teleology account, the teleological bias is, in part, caused by explanatory gaps—that is, by uncertainty (Kelemen, 1999a). If children appeal to teleology at a higher rate when they are uncertain, and uncodeable answers reflect uncertainty, then many uncodeable answers may otherwise have been teleological. This suggests that the open-ended task is a highly conservative measure of the extent and consistency of the teleological bias during early childhood and also a highly conservative measure of its decline over development—because this decline would be partially counteracted by an increasing number of uncodeable responses with lower grade level. In contrast, when provided with two possible answers to select from (in the second task), these low-confidence participants may have been more likely to provide an answer—giving this closed-ended measure greater sensitivity to pick up on underlying teleological biases. This sensitivity difference may also explain the apparent discrepancy in level of teleological bias between the two tasks. It is notable that even with these constraints, participants' open-ended explanations of origins show the same developmental trajectory as seen in the closed-ended task—initial broad bias for teleological and agentic explanations, and increasing selectivity with increasing grade.

General discussion

Overall, we find evidence that children from China show a broad bias for teleological explanations, whereas adults in China use teleological explanations selectively and only when scientifically warranted. In a first experiment, young children endorsed teleological explanations of the properties of living and nonliving natural phenomena equally often across scientifically warranted and unwarranted domains and across scientifically warranted and unwarranted functional content. With increasing grade level, participants used teleological explanations in a more restricted way, increasingly reserving them for self-serving properties of living things. Overall, the pattern and levels of endorsement were roughly comparable to those seen in the Western cultural context of the United Kingdom, another relatively secular nation (Kelemen, 2003). In a second experiment, we explored explanations of the origins of natural phenomena and artifacts, and again found that children endorsed scientifically unwarranted teleological explanations of living and nonliving natural phenomena at a rate higher than adults, doing so across both open- and closed-ended methods. This tendency to teleologically explain why entities such as birds, mountains, and thunderstorms came into being similarly declined and became more specific with increasing grade level. Again, the pattern was roughly comparable to that previously observed in the United Kingdom (Kelemen & DiYanni, 2005).

This pattern of findings is not consistent with the idea that the teleological bias is caused by a relational–deictic cognitive style—the tendency to categorize items relationally (a bird goes with its environment, the sky) rather than categorically (a bird goes with another animal, a dog) (ojalehto et al., 2013). Chinese adults tend to categorize items relationally, whereas Western adults do not (Ji et al., 2004; Markus & Kitayama, 1991; Nisbett, 2003), and this tendency toward relational reasoning and attention develops early in childhood, by 4 years of age (Imada, Carlson, & Itakura, 2013; Kuwabara & Smith, 2012). Although cognitive style was not directly measured in the current work, previous findings indicate that both Chinese children and adults should have a greater tendency toward relational reasoning than Western individuals. Therefore, the relational–deictic account predicts that not only children but crucially Chinese adults should show a greater teleological bias. In contrast to these predictions, Chinese adults show no general propensity to teleological explanation. When explicitly explaining both the origins and properties of different phenomena, Chinese adults endorsed teleological explanations in the same way as Western adults (Kelemen, 1999c; Kelemen & DiYanni, 2005): They reserved them for domains where they are scientifically warranted.

These data are also not consistent with the conclusion that a broad teleological tendency results solely from cultural factors that are shared across the Western groups studied previously but are not features of a secular East Asian culture such as China (e.g., Kelemen, 1999c; Kelemen & DiYanni, 2005; see also Casler & Kelemen, 2008). That is, a high level of Abrahamic religiosity or talk of creationist design in the surrounding culture does not appear to be necessary for the bias to develop. Similarly, the general cultural milieu provided by a Western philosophical heritage does not seem to be necessary either.

To our knowledge, teleological reasoning has been studied in only one non-Western culture previously (indigenous Quechua speakers in Peru), but in this culture participants were expected to show a strong teleological bias due to high levels of explicit teleological and agentic talk about natural phenomena (Gelman et al., 2015; Sanchez Tapia et al., 2016). By contrast, the current research focused on a stronger test of universality—whether broad teleological tendencies develop in a culture that not only is non-WEIRD, but also is one of the least explicitly theistic in the world. Our results show that these broad teleological tendencies still develop: Despite a cultural context that is overtly secular, young children still show generalized tendencies to both invoke and endorse teleological explanations for natural phenomena. Therefore, it seems likely that broad teleological reasoning is based on universal cognitive factors, with cultural factors playing a secondary role in moderating the strength of the bias (e.g., Diesendruck & Haber, 2009) and the time course by which the bias in explicit reasoning declines (Casler & Kelemen, 2008). These data are in line with a promiscuous teleology account of early development, which posits that children's broad teleological bias is a product of their understanding of intentionality, agency, and goal-directed action—a form of explanation that appears to be universally intuitive and early developing.

The current findings are also consistent with recent findings suggesting that an implicit bias toward teleological explanation may be maintained even after explicit beliefs change, in line with a dual-processing account (Kelemen, 1999c, 2004; Kelemen & Rosset, 2009; Kelemen et al., 2013; Rottman et al., 2016; see also Järnefelt, Canfield, & Kelemen, 2015). Specifically, in the current experiments, Chinese adults endorsed teleological explanations selectively only when scientifically warranted. This mirrors explicit judgment patterns found in previous studies on adults' teleological reasoning in Western countries (e.g., Casler & Kelemen, 2008; Kelemen, 1999c). However, one proposal of the promiscuous teleology account is that, once developed, broad teleological intuitions persist throughout development as a default or heuristic mode of explanation. By this account, a scientific education—and formally schooled physical-causal knowledge—may yield reflective explanations that suppress scientifically unwarranted teleological ideas, but an underlying implicit automatic bias to reason in purpose-based terms never disappears.

Consistent with this proposal, when Western adults have minimal schooling, they show a broad teleological bias (Casler & Kelemen, 2008), as do Alzheimer's patients whose semantic knowledge base has been degraded by the disease (Lombrozo, Kelemen, & Zaitchik, 2007). Furthermore, even highly schooled Western adults (e.g., professional physical scientists) default to scientifically unwarranted teleological explanations when judging explanations of natural phenomena under cognitive load during speeded judgment tasks (Kelemen & Rosset, 2009; Kelemen et al., 2013). Most recently, Chinese adults have also been found to default to scientifically unwarranted teleological explanations during speeded judgments (Rottman et al., 2016). Findings from the current experiments complete the cross-cultural picture by showing that explicit adult reasoning also reflects a cross-culturally recurrent developmental trajectory: Like Western adults, Chinese adults expressed selective, scientifically warranted teleological judgments in explicit judgment tasks in spite of previous evidence showing an implicit teleological bias.

Notably, Chinese undergraduates were found to have higher levels of scientific knowledge than their American undergraduate counterparts (Rottman et al., 2016). Across both Western and Chinese adults, independently assessed formal scientific knowledge has been found to contribute to individual differences in teleological bias (Kelemen & Rosset, 2009; Kelemen et al., 2013; Rottman et al., 2016; see also Casler & Kelemen, 2008). This suggests that some of the individual differences in children's levels of teleological bias noted in the current dataset might be accounted for by differing levels of acquired scientific knowledge.

Individual differences in teleological bias may also be caused by differing levels of folk religious practice. Although most of the Chinese population does not identify as formally religious, folk religious practices and beliefs are common (e.g., veneration of ancestors, consulting of fortune-tellers; Paper, 2008; Wong, 2011; Yang & Hu, 2012). Chinese traditional concepts of nature also include agentic ideas such as beliefs about a divine natural order and a vitalistic life force (Paper, 2008; Paton, 2007). Recent work has found high endorsement of "Gaia" belief—belief in nature as an animate being—in a Chinese student sample from rural and urban China (Järnefelt, Zhu, Canfield, Chen, & Kelemen, 2016). Whereas China's widespread formal rejection of religion offers the most relevant sample for testing whether children's teleological beliefs are caused by religious or Western culture, folk beliefs and practices may influence teleological ideas. Indeed, the current data together with previous work in the United Kingdom, the United States, and Israel (e.g., Diesendruck & Haber, 2009; Kelemen, 2003) suggest a developmental story in which a teleological bias is universal during early childhood, with cultural experience then modulating the strength of the bias. Overall, these data provide the strongest evidence to date that children's bias for teleological explanations is not solely a product of Western culture but rather is robust to religious, cultural, and philosophical cross-cultural differences—suggesting that the bias for function-based explanations may be driven by universal aspects of human cognition even as culture moderates its expression over time.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jecp.2016.12.006.

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