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The Cultural Transmission of Explanations: Evidence that Teleological Explanations are Preferentially Remembered

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Abstract

Teleological explanations – explanations in terms of functions, purposes, or goals – are pervasive in religion and feature prominently in intuitive theories about the world, such as theory of mind and folk biology. Previous findings suggest that such explanations reflect a deep, explanatory preference. Here we explore the mechanisms underlying the prevalence and persistence of such explanations, following a method developed by Boyer and Ramble (2001) to examine which religious concepts are likely to survive processes of cultural transmission. Specifically, we test the prediction that novel teleological explanations are remembered better than mechanistic explanations, even when effects of an explanation's quality are taken into account. Two experiments support this prediction for artifact and biological trait explanations, but find the opposite pattern for explanations of non-living natural entities.

Keywords: explanation; teleological explanation; functional explanation; religion; memory; cultural transmission

Introduction

Why-questions are ubiquitous, ranging from those a child might ask to those of existential importance. While different questions solicit different answers, there seem to be systematic patterns in the properties of folk explanations (Lombrozo, 2006). Consider the difference between *mechanistic explanations*, which appeal to causal mechanisms, and *teleological explanations*, which appeal to functions and goals. The origin of human life can be explained mechanistically by appeal to evolution, but is often explained teleologically by appeal to some greater purpose.

In this paper we consider why folk explanations are so often teleological, and suggest that part of the answer lies in their mnemonic properties: teleological explanations are more likely to be remembered than mechanistic alternatives, and hence to survive processes of cultural transmission.

Teleology in folk explanations

Teleological explanations pervade intuitive theories. Folk psychological explanations, for example, often appeal to an agent's goals (e.g. Gopnik & Wellman, 1992; Wellman, 1992), while those in folk biology prominently feature biological functions (e.g. Atran, 1994). Teleological explanations even figure in early physics, as in Aristotle's appeals to teleological causation (Aristotle, Physics II).

Teleological explanations are particularly prominent in religion. Consider, for example, explanations for the origin of the universe. In the familiar Judeo-Christian creation story, the Old Testament God forms trees and animals for man to use (KJV, Genesis, 2:9, 2:18). Appeals to functions and goals likewise infuse the explanations for more mundane goods: we have wine because it "makes glad the heart of man," and bread because it "strengthens man's heart" (KJV, Psalm 104:14, 15).

What accounts for the prevalence of teleology in folk explanations? One possibility is that teleological explanations are common because they correspond to the structure of the world. This possibility is at best incomplete given that so many teleological folk explanations extend beyond those sanctioned by contemporary science (e.g. Kelemen & Rosset, 2009).

A second possibility is that teleological explanations are common because they are psychologically privileged, meaning that they are found more satisfying and generally preferred over alternatives. Evidence for this possibility comes from a growing literature on 'promiscuous teleology' demonstrating that young children prefer teleological explanations (e.g. "clouds are for raining"), and that this preference may persist into adulthood (Lombrozo, Kelemen, & Zaitchik, 2007; Kelemen and Rosset, 2009). Moreover, teleological and mechanistic explanations have unique consequences for categorization (Lombrozo, 2009). While some have suggested that teleological explanations are privileged in only some domains, such as folk biology (Atran, 1994, Keil, 1994), others suggest the preference is more widespread (Kelemen, 1999).

A third possibility is that teleological explanations are common because they are likely to survive processes of cultural transmission. Specifically, if teleological explanations are more likely to be reliably recalled, one should expect culturally transmitted beliefs such as religion to over-represent such explanations.

The possibility that mnemonic properties play a role in explaining the properties of religious explanations is particularly attractive in light of past research on cultural transmission. Within the domain of religion, Boyer and colleagues have successfully explored the role of memory and transmission in explaining the properties of religious concepts, such as demons and deities (e.g. Boyer, 2003). In these studies, participants read about

religious entities and were later asked to recall as many as possible. Boyer argued that if religious concepts have the properties they do because of cultural transmission, the concepts surviving this process should reflect the characteristics of concepts in the world's religions. Although the details have been disputed (e.g. Gonce et al. 2006; Norenzayan, Atran, Faulkner & Schaller, 2006; Tweney et al. 2006), Boyer's findings are broadly consistent with this proposal.

Beyond the domain of religion, research on iterated learning suggests that small biases in transmission can have large consequences over time (Kirby, 2001; Kalish, Griffiths, & Lewandowsky 2007). In the case of teleological explanations, a small bias in memory could have large consequences for the nature of folk explanations after several generations of transmission.

Our aim in this paper is to explore this third possibility: that teleology pervades folk explanations in part because teleological explanations are more likely to be remembered than mechanistic alternatives. We also explore the relationship between this hypothesis and the idea that teleological explanations are psychologically privileged – and hence deemed more satisfying – in all domains or in some domains.

How might memorability and satisfaction interact? It could be that teleological explanations are better remembered than mechanistic alternatives, and that this is *because* teleological explanations are judged more satisfying. Alternatively, memorability may influence satisfaction. Specifically, explanations that are more reliably encoded or recalled may lead to a greater sense of understanding, and hence be found more satisfying. A final possibility, and the one we favor, is that memorability and satisfaction have a common cause. If teleological and mechanistic explanations are supported by different kinds of representations or have a unique relationship to prior knowledge, both greater satisfaction and enhanced memory could result. By examining whether satisfaction mediates effects of explanation type on memorability we can begin to distinguish these alternatives.

In two experiments, participants read novel explanations that were either teleological or mechanistic and about biological traits, artifact properties, or (in Experiment 2) nonliving natural entities. Memory was then tested with recall and recognition tasks to examine the relationships between explanation type, explanation satisfaction, and memory.

Experiment 1

Experiment 1 examines whether teleological or mechanistic explanations are more reliably recalled and recognized. Additionally, it examines the relationship between explanations' memorability and their rated satisfaction, plausibility, detail, and unfamiliarity.

Explanation satisfaction and plausibility ratings were included to examine whether these factors mediate memorability. Ratings for detail and unfamiliarity were added because previous research suggests that explanations of moderate detail (Frazier et al, under review) and moderate unfamiliarity (Boyer & Ramble, 2001) are better remembered. By soliciting detail and unfamiliarity ratings we can examine whether memory differences, if found, result from differences in the detail or familiarity of the novel teleological and mechanistic explanations generated for the experiment. Having participants rate explanations along these four dimensions additionally provided a task to ensure that explanations were encoded prior to the memory tests.

Participants

One-hundred University of California students and community members (68% female, mean age = 22) participated in exchange for course credit or monetary compensation.

Materials and Procedure

The experiment involved twenty why-questions: ten regarding artifact properties and ten regarding biological traits. Each why-question had four possible answers of approximately equal length, two teleological and two mechanistic, for a total of 40 explanations of each type. Tables 1 and 2 provide sample why-questions and answers for each domain.

Table 1: Sample artifact trait explanations.

An istup is a kind of shovel with a compressible handle. Why do istups have compressible handles?
Teleological A: Because that way they can be used by aliens of various heights.
Teleological B: Because that way they can fit inside a regular toolbox.
Mechanistic A: Because the handle is made of distinct, interlocking segments.
Mechanistic B: Because the handle has hinges that allow it to fold.

These explanations were divided into four stimulus sets. In each set, half the questions were mechanistic and half teleological, with equal numbers across domains.

Data were collected via a computerized survey in a laboratory setting. Participants were instructed that they would "learn about the properties of plants, animals, and objects from alien planets and civilizations" and "receive explanations for those properties." Each participant was presented with explanations from a single stimulus set, and was asked to rate each explanation along four dimensions: satisfaction, plausibility, detail, and unfamiliarity. These scales

ranged from 1 (not at all satisfying, plausible, detailed, or unfamiliar) to 7 (very satisfying, very plausible, etc.).

Table 2: Sample biological trait explanations.

Bligs are a kind of animal with fur that is blue. Why do bligs have blue fur?
Teleological A: Because that way they can hide from predators in their environment, which contains blue rocks.
Teleological B: Because that way they can attract others of their species, who are drawn to blue.
Mechanistic A: Because of their mineral-rich diet, which contains compounds that are blue.
Mechanistic B: Because the surface of their planet contains fine, blue dust that sticks to their fur.

Following this encoding task, participants completed 24 distractor questions involving "Alien Math" which took 3 minutes to complete. Participants then completed a cued recall task and a recognition task. The cued recall task involved prompts such as the following:

> You previously saw the following: "Bligs are a kind of animal with fur that is blue. Why do bligs have blue fur?" What was the answer provided for this question? Please reproduce the answer you received as accurately as you can.

This prompt was repeated for each why question.

In the recognition task, the 20 why-questions were again repeated along with four candidate answers. The four answers included the one previously seen by that participant, as well as three additional answers for that why-question drawn from the three unpresented stimulus sets.

Participants were randomly assigned to a stimulus set. The question orders for encoding, recall, and recognition were randomized, as were the multiple-choice answers in the recognition task.

Results and Discussion

To analyze recall data, two independent coders categorized participant responses to cued recall questions as correct or incorrect/absent based on whether the explanation captured the gist of the mechanism or function. Coder agreement was 93%.

Recall accuracy was analyzed as a dependent measure in an ANOVA with explanation type and domain as within-subjects factors. This analysis revealed significant main effects of explanation type, $F(1,99)=25.5$, $p<.01$, and domain, $F(1,99)=7.90$, $p<.01$, with teleological explanation recalled more reliably than mechanistic explanations, and explanations for artifacts recalled more reliably than explanations for biological traits (see Fig. 1).

Recognition errors were analyzed as the dependent measure in an equivalent ANOVA, revealing a main effect of explanation type, $F(1,99)=5.05$,$p<.05$. Participants made an average of .83 errors (of 10) for teleological explanations, and 1.06 errors for mechanistic explanations.

These results suggest differential memory for teleological and mechanistic explanations, with teleological explanations remembered more reliably. To examine whether these effects stem from differences in the rated satisfaction, plausibility, detail, or unfamiliarity of teleological versus mechanistic explanations, the two analyses above were repeated as Linear Mixed Model analyses with satisfaction, plausibility, detail, and unfamiliarity as covariates. The main effect of explanation type on recall remained statistically significant, $F(1,396)=10.05$, $p<.01$; the effects of domain on recall and of explanation type on recognition did not. Notably, however, the explanations did differ in satisfaction, with higher ratings for the teleological explanations, $t(99)=5.71$, $p<.01$ (see Table 3).

Table 3: Mean satisfaction ratings in Experiment 1.

Biological Mechanistic	Biological Teleological	Artifact Mechanistic	Artifact Teleological
4.32	4.86	3.90	4.16

While these findings are consistent with several hypotheses, they suggest that differential recall is not a product of differential satisfaction. Instead, memorability and satisfaction may have a common cause, potentially stemming from the way teleological explanations relate to prior knowledge.

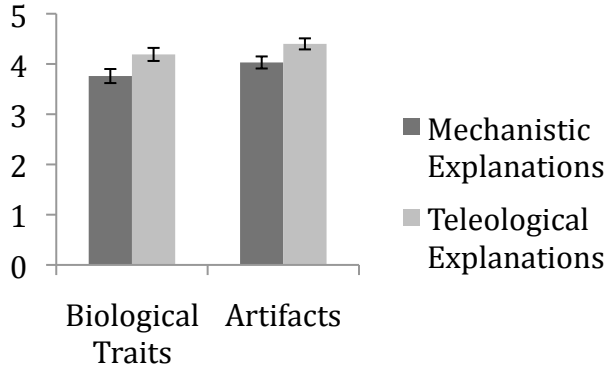

Figure 1: Recall accuracy in Experiment 1.

Experiment 2

Experiment 1 finds that teleological explanations are better remembered in two domains for which teleology is warranted. Are the mnemonic benefits of teleological explanation restricted to these domains, or do they extend more broadly? One aim of Experiment 2 is to

examine this question by extending the task to include nonliving natural entities (NNEs), such as lakes and mountains, which do not typically support teleological explanations.

Experiment 2 additionally aims to examine the nature of memory errors. To increase errors, Experiment 2 involves a larger number of explanations: 10 why-questions for each domain (artifacts, biological traits, NNEs), with one teleological and one mechanistic explanation for each why-question. Of particular interest are errors in explanation type, such as a mechanistic explanation that is "misremembered" as a teleological explanation, as systematic trends in error type could have implications for the cultural transmission of explanations. We target this issue in the recognition task by including two between-subjects conditions: one examining within-explanation type errors (e.g. teleological to teleological), and the other between-explanation-type errors (e.g. mechanistic to teleological).

Participants

Sixty University of California students and community members (72% female, mean age = 19 have participated for course credit or monetary compensation.

Materials and Procedure

The stimuli from Experiment 1 were augmented with 10 new why-questions involving the properties of Nonliving Natural Entities (NNEs), such as lightning and lakes. Four explanations for each question were generated as in Experiment 1 (see Table 4).

Table 4: Sample nonliving natural entity explanations.

A wernuct is a type of geyser that shoots very high into the air. Why do wernucts shoot high into the air?
Teleological A: Because that way giant reptiles can bathe under them.
Teleological B: Because that way the surrounding foliage can remain lush.
Mechanistic A: Because pressure builds up under ground and shoots water through cracks in the planet surface.
Mechanistic B: Because hot temperatures underground cause steam in the water, increasing its reach.

Explanations were subdivided into two stimulus sets, with each set containing a single teleological and mechanistic explanation for each why question.

The procedure mirrored Experiment 1, with the following modifications. In the explanation encoding task, participants saw each why-question twice: once presented with a teleological explanation, and once with a mechanistic explanation.

The distraction and recall tasks were identical to Experiment 1. Note that the recall prompt asked participants to report the answer to the question that they had previously seen; they were not explicitly prompted to provide two explanations.

There were two versions of the recognition task. In each version, participants received all 30 why-questions with two candidate responses: either one teleological and one mechanistic (between-type condition) or two of the same type (within-type condition), with the unseen explanations drawn from the unseen stimulus set.

Participants were randomly assigned to stimulus set and to recognition condition (between-type or within-type). Questions were presented randomly, but separated into two blocks, with order counterbalanced across participants, such that participants would see one answer for each why-question before seeing a second answer to any question. Answers for the recognition test were presented in random order.

Results and Discussion

Coding for the recall portion of the experiment was completed as in Experiment 1, with 88% agreement.

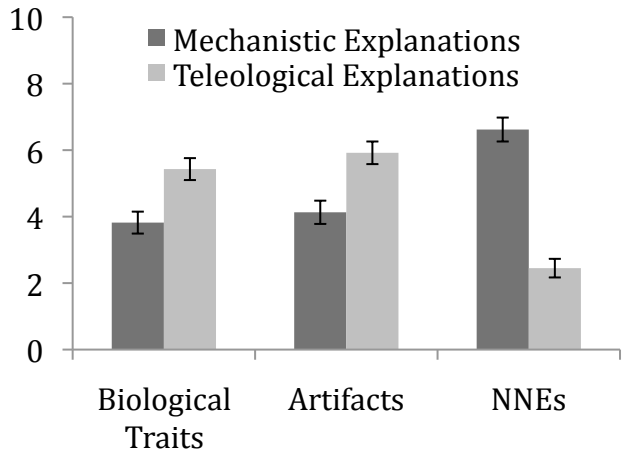

Figure 2: Recall accuracy in Experiment 2.

Recall accuracy was analyzed as a dependent measure in an ANOVA with explanation type and domain as within-subjects factors (see Fig. 2). This analysis revealed a significant effect of domain, $F(2,58)=13.4$, $p<.01$, as well as an interaction between explanation type and domain, $F(2,58)=70.5$, $p<.01$. Paired samples t-tests comparing recall for teleological and mechanistic explanations within each domain revealed significant differences, but in different directions. Teleological explanations were recalled more reliably than mechanistic explanations for biological traits, $t(59)=-3.91$, $p<.01$, and for artifacts, $t(59)=-4.39$, $p<.01$, replicating Experiment 1. In contrast, mechanistic explanations were recalled more reliably than teleological explanations for NNEs, $t(59)=8.94$, $p<.01$.

To determine whether these differences were driven by the satisfaction, plausibility, detail, or unfamiliarity of stimulus items, recall accuracy was analyzed separately for each domain in a Linear Mixed Model with explanation ratings as covariates. This analysis confirmed that teleological explanations were more reliably recalled than mechanistic explanations for biological traits, $F(1,118)=12.1$, $p<.01$, and artifacts, $F(1,118)=13.6$, $p<.01$, with the reverse pattern for NNEs, $F(1,118)=82.9$, $p<.01$. We did not replicate the satisfaction difference between mechanistic and teleological explanations found in Experiment 1.

Recognition errors were analyzed as the dependent measure in an ANOVA with explanation type and domain as within-subjects factors. This revealed a main effect of explanation type, $F(1,59)=63.9$,$p<.01$, with better recognition for teleological than mechanistic explanations (26.4 versus 22.4 of 30). There was also a main effect of domain, $F(2,58)=78.9$, $p < .01$, with better recognition for NNE (17.8/20) and artifact (17.7) explanations than for biological trait (13.3) explanations. Finally, there was an interaction between explanation type and domain, $F(2,58)=37.7$, $p<.01$, with teleological explanations recognized more reliably than mechanistic explanations for biological traits and for artifacts, but a non-significant trend in the reverse direction for NNEs (9.1 versus 8.8). These patterns of significance remained identical in a Linear Mixed Model with explanation ratings (satisfaction, etc) as covariates.

To examine the nature of memory errors, recognition accuracy was analyzed as the dependent measure in an ANOVA with recognition test (within-type versus between-type) as a between-subjects factor and explanation type as a within-subjects factor. This analysis confirmed the main effect of explanation type on recognition accuracy, $F(1,58)=75.3$, $p<.01$, with teleological explanations recognized more reliably than mechanistic explanations, and also revealed an interaction between explanation type and recognition test, $F(1,58)=11.5$, $p<.01$. Teleological explanations were correctly distinguished from teleological lures about as often as they were correctly distinguished from mechanistic lures (26.9 versus 25.8). In contrast, mechanistic explanations were more likely to be correctly distinguished from teleological lures than from mechanistic lures (23.4 versus 21.4). This suggests that mechanistic explanations were more "interchangeable" than teleological explanations.

It is worth noting that despite the sizeable advantage for mechanistic explanations of NNEs in recall, recognition performance was comparable for both teleological and mechanistic explanations. This suggests that recall performance may have reflected a preference to report warranted explanations in addition to or instead of differential effects of memory.

General Discussion

Experiments 1 and 2 suggest that when it comes to explaining the properties of biological traits or artifacts, teleological explanations are recalled more reliably than mechanistic alternatives. However, when it comes to explaining the properties of nonliving natural entities, mechanistic explanations are recalled more reliably than teleological alternatives. These effects persist when explanations' satisfaction, plausibility, detail, and unfamiliarity are taken into account.

Data for recognition were more variable, but yielded two suggestive results. First, mechanistic explanations were more likely to be "misrecognized" as other mechanistic explanations, suggesting that mechanistic explanations generated less distinctive memories. Second, despite the overwhelming advantage for mechanistic explanations of non-living natural entities in recall, recognition performance was comparable for teleological and mechanistic explanations, suggesting that even unwarranted teleological explanations were remembered remarkably well.

The current findings suggest that memory for teleological explanations is privileged in domains for which such explanations are typically warranted – namely biological traits and artifacts – but do not rule out the possibility that memory benefits extend more broadly. In follow-up work, we plan to explicitly prompt participants to report all provided explanations in recall, thereby helping to identify whether the benefit for mechanistic explanations of NNEs resulted from a genuine difference in memory or a preference to report explanations that are believed to be warranted.

While the memory differences we find are small – especially for recognition – models of cultural transmission suggest that small biases can quickly magnify over time (Kirby, 2001; Kalish, Griffiths, & Lewandowsky 2007). Thus a modest tendency to recall or report teleological explanations could result in a disproportionate representation of such explanations after only a few generations. When it comes to religious explanations, which are arguably less responsive to data than explanations in scientific or folk theories, biases in transmission may be responsible for systematic trends across the world's religions (see also Boyer, 2003).

We conclude by considering three important questions for future research. First, to what extent are differential effects of teleological and mechanistic explanations driven by the close relationship between teleology and intentional agency? Could it be that it is intentional explanations, not teleological explanations, that are preferentially remembered? While our effects extended to biological traits, it could be that participants construed the biological organism or natural selection as an intentional agent. Research suggests a close correspondence between teleology and intentional agency (e.g. Kelemen & DiYanni, 2005), but there is also

evidence that teleological explanations are reliably distinguished from intentional explanations (Lombrozo & Carey, 2006).

Second, to what extent are there individual differences in memory and transmission biases when it comes to explanations? In particular, what is the relationship between an individual's religious commitments and differential memory for explanation types? There is already some evidence that scientific training decreases teleological tendencies (Casler & Kelemen, 2008), while science training is inversely related with belief in god (Larson & Witham, 1997), particularly for top scientists (Larson & Witham, 1998).

Finally, and most critically, future research will need to explore the basis for differential memory for teleological and mechanistic explanations. Examining the contributions of explanation satisfaction, plausibility, detail, and unfamiliarity is a first step, as is considering a range of domains. But what is it about some explanations that make them more memorable, and hence more likely to survive processes of cultural transmission? We speculate that teleological explanations may be encoded differently from beliefs about causal mechanisms, and may have a more integrated relationship to prior knowledge. Of course, these speculations require further elaboration and empirical examination.

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