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Young children's learning and generalization

of teleological and mechanistic explanations

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Abstract

Young children often endorse explanations of the natural world that appeal to functions or purpose, explaining (for example) that rocks are pointy so animals can scratch on them. By contrast, most Western-educated adults reject such explanations. What accounts for this change? We investigated 4- to 5-year-old children's ability to generalize the form of an explanation from examples by presenting them with novel teleological explanations, novel mechanistic explanations, or with no explanations for five nonliving natural objects. They were then asked to explain novel instances of the same objects and novel kinds of objects. We found that children were able to learn and to generalize explanations of both types, suggesting an ability to draw generalizations over the form of an explanation. We also found that teleological and mechanistic explanations were learned and generalized equally well, suggesting that if a domain-general teleological bias exists, it does not manifest as a bias in learning or generalization.

Keywords: teleological explanation, functional explanation, mechanistic explanation, explanatory preferences, learning, generalization

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The popular children's book *Look Look!* endearingly concludes by telling its young readers that "stars shine all for you" (Linenthal, 1998). While Western adults might balk at this purposive take on properties of the nonliving natural world, it isn't foreign to most young children. In fact, given the choice between explaining why particular rocks are pointy by appeal to a purpose ("so that animals…could scratch on them") or by appeal to a mechanical process ("because little bits of stuff piled up on top of one another over a long time"), most elementary school students opt for explanations like the former (Kelemen, 1999a; see also Piaget, 1929; Sully, 1900). With age and education, however, this tendency becomes more selective (e.g., Casler & Kelemen, 2008; Kelemen, 1999b). For most Western adults, "teleological" or "functional" explanations – explanations that appeal to a purpose, function, or goal – are restricted to artifacts and some biological traits (Lombrozo & Carey, 2006). So while most will accept that streetlights shine "for us," they won't say the same about stars.

Why do children's teleological preferences change over the course of development? Past work convincingly shows that culture and education play important roles. For example, by 6 years of age, secular Israeli children show a weaker and more circumscribed preference for teleological explanations than orthodox Israeli children (Diesendruck & Haber, 2009; see also Casler & Kelemen, 2008; Kelemen, 2003; Rottman et al., 2017). There's also evidence that adults with greater exposure to western education are more selective in their application of teleological explanations (Casler & Kelemen, 2008; Sánchez Tapia et al., 2016). Moreover, culture can affect the content of teleological explanations: a study comparing Quechua-speaking Peruvians with Americans found that the former group

produced more teleological explanations involving ecological relationships (Sánchez Tapia et al., 2016; see also ojalheto, Waxman, & Medin, 2013). These findings indicate that there must be some mechanism(s) by which exposure to particular cultural or pedagogical materials, practices, or contexts affects the perceived scope of teleological explanations.

One possibility is that as children hear particular explanations, they form generalizations concerning the kind of explanation involved (i.e., teleological or mechanistic) and the kind of entity to which it is being applied (e.g., a human artifact, or a nonliving natural thing). For example, after hearing many mechanistic explanations for nonliving natural things (e.g., those mountains resulted from volcanic activity, the rain is a result of water droplets forming in clouds…), children could form the generalization that nonliving natural things tend to support mechanistic explanations. But the prerequisites to this kind of generalization are not trivial: children must be able to represent *kinds* of explanations as such and to group objects into classes that have some correspondence to explanation type. In fact, the single study that attempted to teach children to produce mechanistic explanations did not succeed: Kelemen (1999a, 2003) attempted to train children to select mechanistic explanations over teleological alternatives by providing them with an example of how a scientist would explain cloud formation (e.g., clouds "are all made up of tiny drops of water and sometimes when the water drops get really cold then it rains," p. 207, Kelemen, 2003). This training had very little effect on subsequent explanation choices, with most children endorsing teleological explanations for most item types.

In the current study, we aim to investigate whether children can successfully generalize an explanation type from one case to another by implementing a training regime that might be a better match to children's everyday experience. Rather than providing a single extended example

with the additional instructions to answer "like a scientist," we present children with multiple explanations of a particular type, and we then assess learning and generalization. Specifically, we introduce 4- and 5-year-old children to five examples of nonliving natural objects (e.g., stars) from a fictional planet, Bizorm. Each object is introduced with no explanation (e.g., "Wow, look at this!"), with a teleological explanation ("Stars on Bizorm are very bright yellow so that people can see them"), or with a mechanistic explanation ("Gas burns in the stars on Bizorm so they are very bright yellow"). We then solicit explanations from children in two tasks: a *learning* test and a *transfer* test. In the learning test, we assess how effectively the provided explanations were remembered and applied by asking children to explain novel instances of the same kinds of objects (e.g., another star). In the transfer test, we ask children to explain the properties of nonliving objects or phenomena that were not previously seen (e.g., a river).

The transfer test is especially crucial for assessing whether the *type* of explanation modeled in training generalizes to novel items. To do so, we can see whether the children in the teleological training condition generate more teleological explanations on the transfer test than do children in the control condition (who receive no training), and whether the children in the mechanistic training condition generate more mechanistic explanations on the transfer test than do children in the control condition. In both cases it's important to consider children's responses relative to the control condition, rather than in absolute terms, to ensure that preferences for one explanation type over the other are driven by the training itself, and not by the spontaneous explanatory preferences that children might have concerning those items, even in the absence of training.

By testing children's learning and transfer for both mechanistic and teleological explanations, our experiment also has the potential to shed light on ongoing debates about the scope of teleological reasoning. According to one perspective, teleology reflects a "default" and domain-general preference to reason about the world in terms of function and purpose (Kelemen, 1999c). This perspective is supported by evidence that children accept teleological explanations across domains (Kelemen, 1999a), and that this preference is not a simple consequence of parental input: parents do not provide a disproportionate number of teleological explanations in child-directed speech (Kelemen, Callanan, Casler, Pérez-Granados, 2005). Moreover, adults err in the direction of accepting scientifically-unwarranted teleological explanations when responding under time pressure (Kelemen & Rosset, 2009; Kelemen, Rottman, & Seston, 2013) or when cognitively impaired (Lombrozo, Kelemen, & Zatchik, 2007), suggesting that a preference for teleological explanations could persist as a default preference throughout the lifespan.

An alternative perspective is that teleological explanations reflect a more selective "design stance" that is restricted to reasoning about the products of intentional or apparent design, namely artifacts and biological adaptations (Keil, 1992, 1994). Supporting this view, Greif, Kemler Nelson, Keil, and Gutierrez (2006) found that children sometimes asked function-seeking questions for artifacts (e.g., ''what is it for?''), but never did so for animals. It's also worth noting that while children do tend to accept teleological explanations for animals and for non-living natural things when they are offered, they do so significantly more often for artifacts and for biological adaptations, suggesting some selectivity operating over what may be a baseline preference. Similarly, while adults accept some scientifically-unwarranted teleological explanations under speeded conditions (e.g. "earthworms tunnel underground to aerate the soil"),

they do not accept teleological explanations that are treated as "bad" control items (e.g., "cars have horns to illuminate dark roads") (Kelemen & Rosset, 2009). These findings suggest some selectivity in the scope of teleological explanations.

Given these ongoing debates, a secondary goal of the present research is to revisit questions about the selectivity of teleological explanations using our novel method. Instead of focusing on which explanations children produce (e.g., Sánchez Tapia et al., 2016) or select (e.g., Kelemen, 1999), or on the function-seeking questions children ask (Greif et al., 2006), we focus on how readily children *learn* and *generalize* novel explanations when they are offered. If children favor teleological explanations as a cognitive default, we might expect this to manifest as a learning bias, with teleological explanations more readily learned and generalized than mechanistic explanations, provided such explanations are not already at ceiling. In contrast, if children show some early selectivity in their use of teleological explanations, we might instead expect mechanistic explanations to be more readily learned and generalized in our task, given that the domain of non-living natural objects does not typically involve actual or apparent design. Our method thus provides a new way to address long-standing questions about the selectivity of young children's teleological preferences.

In sum, our experiment investigates how young children learn and generalize teleological and mechanistic explanations by presenting them with no explanations, with novel teleological explanations, or with novel mechanistic explanations, and then soliciting explanations for matched and novel cases. Our study is among the first to consider whether children can form generalizations over explanation types, effectively extending a mode of

explanation from trained instances to novel cases. Our study can also inform ongoing debates about the scope of young children's teleological preference.

Methods

      Participants. Sixty children (mean: 54 months; range: 47-71) were recruited from local preschools (N = 58) or a science museum (N = 2) and randomly assigned to one of three conditions: *neutral baseline, teleological training*, or *mechanistic training*. There were 20 children in each condition, with no significant differences in age, $F(2,57) = 1.362$, $p =$ .264. One additional child was replaced due to experimenter error. The children represented a broad range of ethnicities.

      Materials. A picture book was used in training and included five drawings of nonliving natural objects (pond, mountain, cave, island, star). The learning test for this picture book included an additional five drawings of these objects, modified to be similar but distinguishable. The transfer task used drawings of five new natural objects or phenomena (desert, canyon, thunder, river, volcano). Sample illustrations are provided in Figure 1. (The complete set of stimuli can be found in online supplemental materials.)

Procedure

      Training task. Children were introduced to the five-page training book with drawings of nonliving natural objects from the planet "Bizorm" (see Figure 1, top). A statement accompanied each drawing (see Table 1). In the *Neutral baseline* condition the experimenter provided a neutral statement (e.g., "Wow, look at this!"). In the *Teleological training* condition the experimenter provided a teleological explanation (e.g., "Caves on Bizorm are very dark so that animals can hide in them."). In the *Mechanistic training*

condition the experimenter provided a mechanistic explanation (e.g., "There are no holes for light to shine through in caves on Bizorm, so they are very dark.").

Learning test. After observing all training items, children received the learning test (see Figure 1, middle). The original drawings remained visible as the experimenter introduced five new drawings (e.g., "Here is *another* cave from the planet Bizorm"). Children were then asked why each property held for the objects in the new drawings (e.g., "Why do you think *this* cave is so dark?"). Children were first prompted to provide a free response. After the free response, they were presented with a forced response option that included the explanations provided during the teleological and mechanistic training conditions, with order counterbalanced.

Transfer test. Children were shown five drawings of nonliving natural objects or phenomena from planet Earth (see Figure 1, bottom). As with the learning test, children were prompted to explain a property of each item and then given a forced-choice option between teleological and mechanistic explanations, with order counterbalanced (see Table 2).

Explanation Coding And Preliminary Analyses

Free response coding. Free-response explanations were coded into three non-overlapping categories: "teleological" (appealing to a function or purpose, e.g., "the cave is dark so animals can sleep and hide there from hunters"); "mechanistic" (appealing to proximate causal processes, e.g., "the light can't shine because the holes [are] so small"); or "other" (e.g., repetition of the property in question or description of the picture, "that's how caves are," "this one's big and this one's small"). Eighty percent of children's responses

were coded by both the first and third authors, blind to condition; kappa was .70. The

analyses reported below correspond to those of the first coder, who coded all responses.

It's worth noting that for the learning test in the teleological and mechanistic

training conditions, participants could in principle have produced a teleological or

mechanistic explanation that did not match the one offered in training. However, this

happened very rarely – about seven times in the teleological training condition and twice in

the mechanistic training condition (less than 6% of total explanations). This helps rule out

the concern that the teleological and mechanistic explanations that we happened to use

might be differentially memorable. Moreover, the explanations that were produced in these

cases were often related to the explanations originally provided. For example, one child

trained that caves are dark so that animals can hide in them offered the free response that

they are dark "so they can sleep in there," and a child taught that stars are bright so that

people can see them explained that stars are bright "so people can see in the dark." To

allow for masked coding and consistency in coding across conditions, we therefore coded

explanations as "teleological" or "mechanistic" irrespective of the child's condition or

whether the explanation matched the one that was offered in training.

Forced choice coding. For the forced choice responses, we summed the number of

teleological explanations chosen for the learning and transfer tests. Overall, participants

chose teleological explanations on 2.57 of the 5 learning trials (SD = 1.49), and on 2.49 of

the of the 5 transfer trials (SD = 1.02), neither of which was significantly different from

chance, $t(59)$ = .347, p = .730, and $t(59)$ = -.381, p = .704 (one-sample t-tests). Moreover**,**

forced-choice responses did not differ as a function of condition, even for learning items,

$F(2,57)$ = 1.718, p = *.189.* The forced choice response was given to all children, even those

who had provided a free response that matched one of the options provided; however, this follow-up likely prompted children to change their answer (Gonzalez et al, 2012; Bonawitz et al, *in review*). Given this methodological concern and children's chance responding on this secondary measure, we restrict analyses to the original free response data.

Results

We were interested in two main questions pertaining to children's learning of the explanations and their generalizations. First, how readily did children learn the particular teleological or mechanistic explanations provided during training (as reflected by the learning test), and did children learn one type of explanation more readily than the other? Second, how readily did children generalize the modeled explanation type to novel kinds of objects (as reflected by the transfer test), and did children generalize one type of explanation more readily than the other? We address these questions in turn.

To address the first question, we analyzed free responses on the learning task as a function of condition (see Figure 2). Children produced an average of 1.22 ($SD = $ 1.777) teleological explanations (from a possible range of 0-5), and this number varied as a function of condition, $F(2, 57) = 45.567, p < .001, \eta_p^2 = .615$. Children produced 3.20 ($SD = $ 1.795) teleological explanations in the teleological condition, .30 ($SD = .657$) in the neutral condition, and .15 ($SD = .489$) in the mechanistic condition. Post-hoc Tukey tests revealed that responses in the teleological condition differed significantly from the other two conditions, $p < .001$, which did not differ from each other, $p = .909$.

Because the distribution of teleological responses was skewed towards zero in the mechanistic and neutral conditions, we also conducted a non-parametric independent-samples Kruskal-Wallis test, which confirmed that the distribution of responses differed as

a function of condition, $p < .001$. Comparing pairs of conditions with an independent-samples Mann-Whitney U test similarly confirmed that the teleological condition differed significantly from the mechanistic and neutral conditions, $ps < .001$, which did not differ from each other, $p = .602$.

For mechanistic explanations, children produced an average of 1.30 such responses ($SD = 1.660$) (from a possible range of 0-5) on the learning test, and this number also varied as a function of condition, $F(2, 57) = 34.635$, $p < .001$, $\eta_p^2 = .549$. Children produced .20 ($SD = .410$) mechanistic explanations in the teleological condition, .70 ($SD = 1.174$) in the neutral condition, and 3.00 ($SD = 1.522$) in the mechanistic condition. Post-hoc Tukey tests revealed that responses in the mechanistic condition differed significantly from the other two conditions, $p < .001$, which did not differ from each other, $p = .351$.

Once again, the distribution of mechanistic responses was skewed towards zero in the teleological and neutral conditions. We thus conducted a non-parametric independent-samples Kruskal-Wallis test, which confirmed that the distribution of responses differed as a function of condition, $p < .001$. Comparing pairs of conditions with an independent-samples Mann-Whitney U test similarly confirmed that the mechanistic condition differed significantly from the teleological and neutral conditions, $ps < .001$, which did not differ from each other, $p = .314$.

We next considered whether teleological and mechanistic explanations were learned *differentially*. To do so, we first coded responses in the teleological and mechanistic conditions as training-consistent, i.e., teleological explanations produced in the teleological training condition were coded as matches, whereas mechanistic explanations produced in the mechanistic training condition were coded as matches. Simply comparing the

proportion of matches across conditions, however, could reflect differences in the test

items related to their bias for teleological versus mechanistic explanations, and not

differential effects of learning as a function of the training. We therefore treated responses

in the neutral condition as an indication of how "teleologically-biased" or "mechanistically-

biased" the items were, and used these responses as a baseline correction for the

teleological and mechanistic training conditions. Specifically, we subtracted the mean

number of teleological explanations produced on learning items in the neutral condition

(i.e., .30) from each teleological match score in the teleological condition, and the mean

number of mechanistic explanation produced in the neutral condition (i.e., .70) from each

mechanistic match score in the mechanistic condition.

Having computed these baseline-corrected match scores, which reflect the extent to

which a training condition increased the rate of training-consistent responses over the

(neutral condition) baseline, we used an independent-samples t-test to compare the rate of

training-consistent responses produced in the teleological versus mechanistic conditions.

The result was not significant (teleological: M = 2.900, SD = 1.795; mechanistic: M = 2.300,

SD = 1.522), $t(38)$ = -1.140, p = .261. Addressing our first question, then, these results

suggest that children were able to effectively learn some of the explanations provided

during training, but that teleological and mechanistic explanations were learned equally

readily.

To address our second question, we analyzed free responses on the transfer task as

a function of condition (see Figure 3). Children produced an average of .62 (SD = 1.106)

teleological explanations (from a possible range of 0-5), and this number varied as a

function of condition, but only marginally, $F(2, 57)$ = 2.459, p = .095, η_p^2 = .079. Children

produced 1.05 (*SD* = 1.395) teleological explanations in the teleological condition, .35 (*SD* =

.489) in the neutral condition, and .45 (*SD* = 1.146) in the mechanistic condition. Post-hoc

Tukey tests revealed that no two conditions differed significantly, *ps* > .01. Because

responses in all conditions were skewed towards zero, we also conducted a non-

parametric independent-samples Kruskal-Wallis test, which similarly failed to find a

significant effect of condition, *p* = .126.

For mechanistic explanations, children produced an average of 2.60 (*SD* = 1.392)

such responses (from a possible range of 0-5), and this number varied as a function of

condition, *F*(2, 57) = 6.333, *p* = .003, η_p^2 = .182. Children produced 2.00 (*SD* = 1.214)

mechanistic explanations in the teleological condition, 2.40 (*SD* = 1.392) in the neutral

condition, and 3.40 (*SD* = 1.231) in the mechanistic condition. Post-hoc Tukey tests

revealed that responses in the mechanistic condition differed significantly from the other

two conditions, *p* < .05, which did not differ from each other, *p* = .588. While responses

were normally distributed, we followed up with non-parametric tests, which mirrored

these patterns of significance.

To evaluate whether teleological and mechanistic explanations were *differentially*

generalized, we again coded the number of training-consistent responses produced in the

teleological and mechanistic training conditions, and subtracted the mean number of

responses of the corresponding type from the neutral condition to serve as a baseline

correction. An independent-samples *t*-test comparing these difference scores was not

significant (teleological: *M* = .700, *SD* = 1.395; mechanistic: *M* = 1.000, *SD* = 1.231), *t*(38) =

.721, *p* = .475. Addressing our second question, then, these results suggest that children

were able to generalize the explanation type learned during training, but that teleological

and mechanistic explanations were generalized equally readily.

General Discussion

Our findings suggest that when it comes to nonliving natural objects such as stars and

caves, 4- to 5-year-old children are able to learn novel teleological and mechanistic

explanations, and to generalize these kinds of explanation to novel items. Moreover, they

are able to learn and generalize these two explanation types equally well. Below we

consider possible interpretations and implications of our results.

Our primary research question concerned the mechanism(s) by which children's

explanatory preferences change over the course of development. Given that culture and

education are both factors, it's plausible that children are able to generalize from individual

explanations that they encounter, coming to learn which *kinds* of explanations apply to

particular kinds of cases. Our findings suggest that children are indeed able to generalize in

this way, with several examples of a particular explanation type sufficient for them to

generate completely novel explanations of that same type. We speculate that our training

was successful, while the training from Kelemen (2003) was not, because we provided

children with multiple examples rather than a single case. From these examples, they were

able to extract the common explanatory form despite variation in content, suggesting some

representation of explanation *type* with respect to which they could note similarities.

Our findings do not reveal the precise nature of the generalization that children

drew. Past work suggests that different kinds of explanations have different causal

commitments (Lombrozo & Carey, 2006). In particular, children are more likely to accept

teleological explanations when they believe the entity being explained was designed or

made by some creator (Kelemen & DiYanni, 2005). One possibility is that children who

received teleological explanations inferred that the objects on planet Bizorm are created or

designed, and it's this causal commitment that was generalized to novel objects. Another

possibility is that explanatory generalizations were made over the explanatory form itself,

without concomitant commitments about causal etiology. This is an important question for

future research.

      Our secondary research questions concerned whether teleological and mechanistic

explanations might be learned or generalized *differentially*. We did not find such effects.

Children were able to learn and to generalize both types of explanations for nonliving,

natural kinds, with no significant differences between them. This result potentially speaks

against the idea of a teleological bias. Insofar as such a bias exists, it did not manifest on our

task. Similarly, our results run counter to the idea that children favor mechanistic

explanations in the domain of nonliving natural things; while there was a baseline

preference (at least in the generalization test items), there was not a bias in learning or

generalization. That said, these conclusions follow from a null result, and should thus be

interpreted with caution. Research on cultural evolution suggests that even very small

biases can generate large differences over time (e.g., Kalish, Griffiths, & Lewandowsky,

2007) and influence the nature of culturally accepted beliefs (Boyer, 2001; Boyer &

Ramble, 2001). So even if children start out with a very weak bias favoring one type of

explanation over the other, this bias could manifest as a strong preference later in

development or later in the course of cultural evolution.

      Our study has several limitations. Given the known effects of age, culture, and

education on explanatory preferences, findings from a single sample should be generalized

with caution. Our study was also restricted to the domain of nonliving natural things. Future work could investigate a wider range of domains, and in so doing explore children's ability to draw generalizations not only over *kinds* of explanations, but also over appropriate *kinds* of entities.

In sum, we find that children are able to learn and to generalize novel teleological and mechanistic explanations, and to do so equally well for both types of explanations. So while young children may occasionally hear that stars "shine all for you," our findings suggest that a greater preponderance of mechanistic explanations in their environment could be enough to curb their teleological tendencies towards the natural world as they grow older.

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Table 1. Statements that accompanied each of the five items in the training task for each

condition, along with the corresponding question that was later asked on the learning test.

Item	Neutral Baseline	Teleological Training	Mechanistic Training	Test question
Pond	"Wow, look at this!"	"Ponds on Bizorm are very still so that the water doesn't spill out"	"No rocks fall into ponds on Bizorm, so they are very still"	"Why do you think this pond is so still?"
Cave	"Wow, look at this!"	"Caves on Bizorm are very dark so that animals can hide in them"	"There are no holes for light to shine through in caves on Bizorm, so they are very dark"	"Why do you think this cave is so dark?"
Star	"Wow, look at this!"	"Stars on Bizorm are very bright yellow so that people can see them"	"Gas burns in the stars on Bizorm, so they are very bright yellow"	"Why do you think this star is so bright yellow?"
Mountain	"Wow, look at this!"	"Mountains on Bizorm are very pointy so that animals don't climb on them"	"Mountains on Bizorm are very pointy because smooth pieces of mountain fall off"	"Why do you think this mountain is so pointy?"
Island	"Wow, look at this!"	"Islands on Bizorm are very small so that ships don't bump into them"	"Islands on Bizorm are very small because the ocean covers most of the land"	Why do you think this island is so small?"

Table 2. Complete set of items for the transfer test, including the teleological and

mechanistic explanations provided for the forced choice question.

Item	Question	Teleological	Mechanistic
Desert	Why do you think this desert is so hot?	[Or] do you think it's so that people don't walk on it?	[Or] do you think it's because there are no trees to shade it?
River	Why do you think this river is so narrow?	[Or] do you think it's so that animals can cross over it?	[Or] do you think it's because not very much water goes through it?
Thunder	Why do you think this thunder is so loud?	[Or] do you think it's so that people know to go inside?	[Or] do you think it's because lightening in the clouds makes a noise?
Canyon	Why do you think this canyon is so deep?	[Or] do you think it's so that things on this side can't cross over to the other side?	[Or] do you think it's because little pieces fell away over a long time?
Volcano	Why do you think this volcano has steam on top?	[Or] do you think it's so that people know to stay away from it?	[Or] do you think it's because the hot lava heated up the inside of the volcano?

Figure 1. Sample stimuli from the picture books used in training (top; pointy mountain and bright stars), in the learning test (middle; pointy mountain and bright stars), and in the transfer test (bottom; hot desert and steaming volcano).
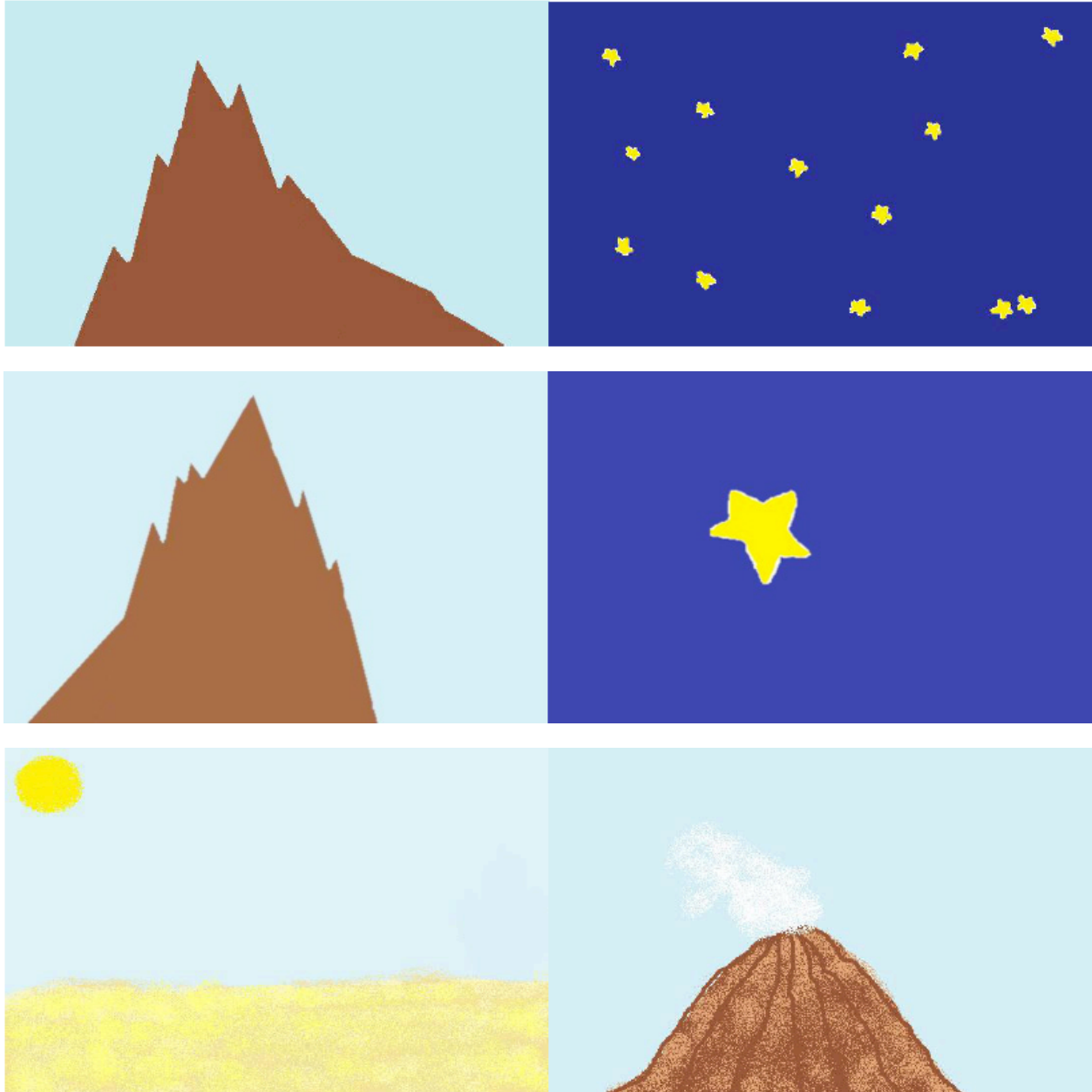
Figure 2. The mean number of teleological and mechanistic explanations offered (of 5) on the learning test as a function of training condition. Error bars correspond to one SEM in each direction.
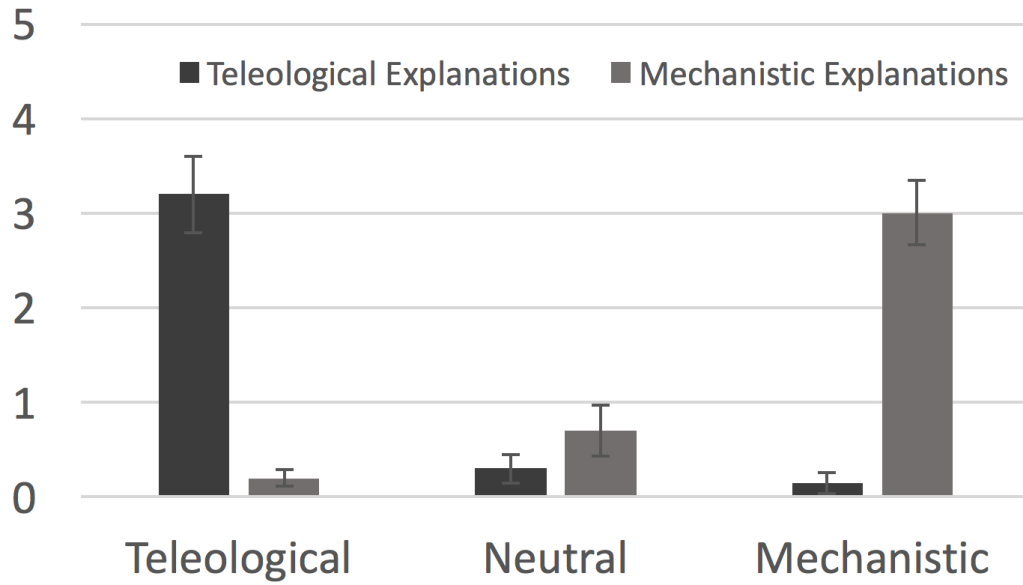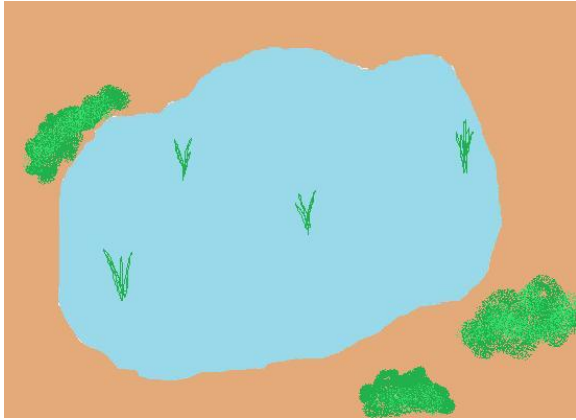
Figure 3. The mean number of teleological and mechanistic explanations offered (of 5) on the transfer test as a function of training condition. Error bars correspond to one SEM in each direction.
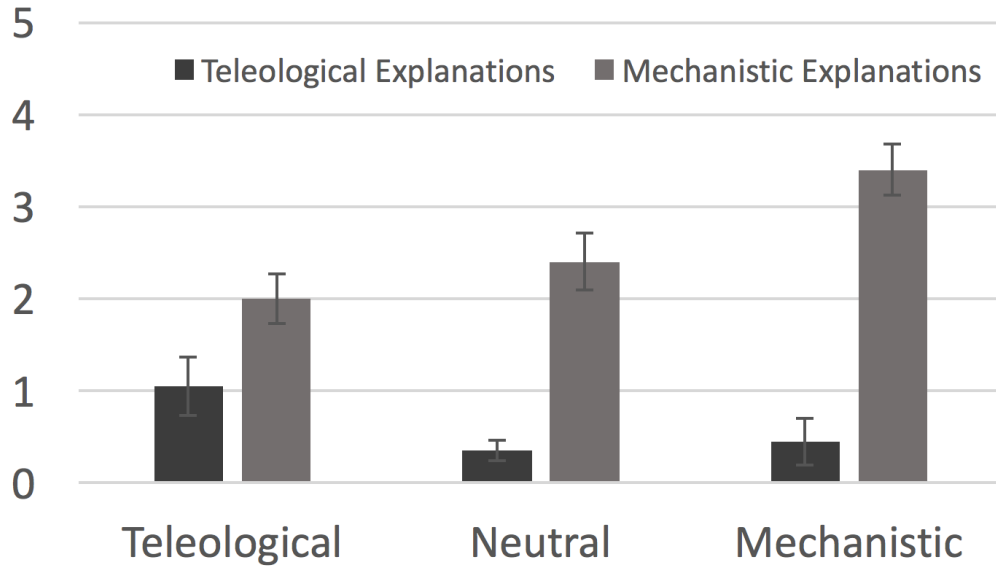
Supplemental Materials

A. The five picture books used in training task (original and test).

Pond

Original

Test

Mechanistic training: No rocks fall into ponds on Bizorm, so they are very still.

Teleological training: Ponds on Bizorm are very still so that the water doesn't spill out.

Neutral statement: Wow, look at this!
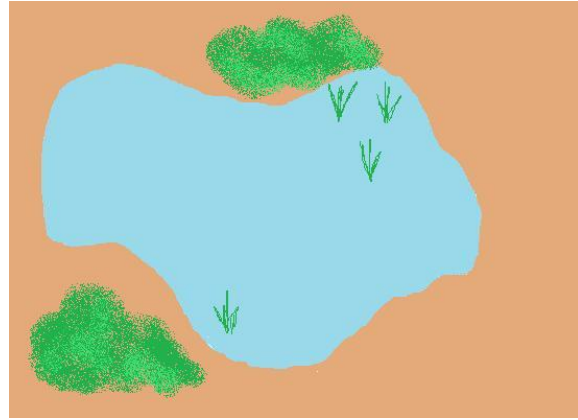
Here is *another* pond from the planet Bizorm. Why do you think this pond is so still?

Mountain

Original
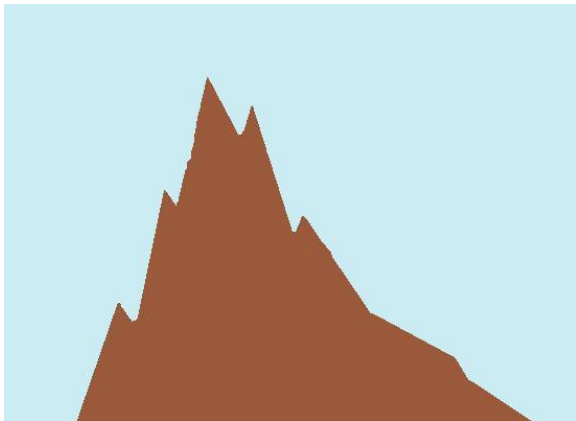
Test

Mechanistic training: Mountains on Bizorm are very pointy because smooth pieces of mountain fall off.

Teleological training: Mountains on Bizorm are very pointy so that animals don't climb on
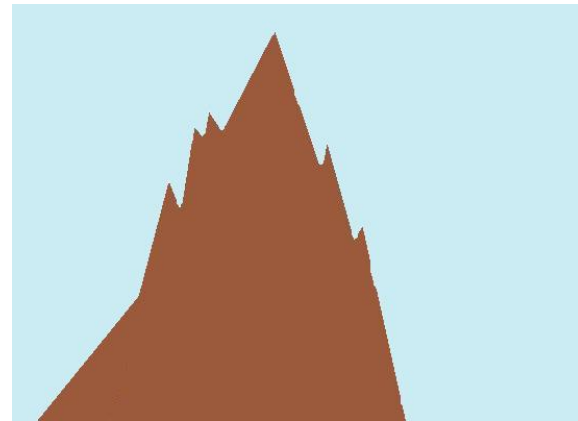
Here is *another* mountain from the planet Bizorm. Why do you think this mountain is so pointy?

them.

Neutral statement: Wow, look at this!

Cave

Original   *Test*
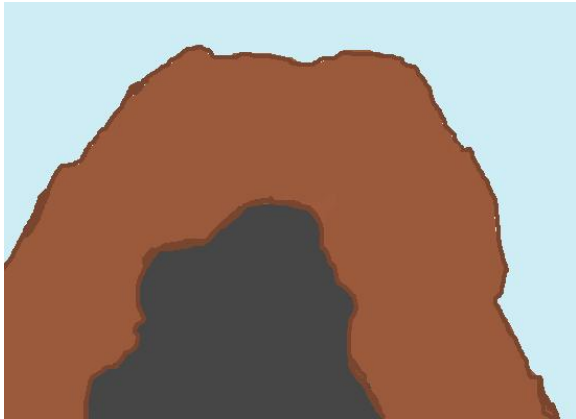
Mechanistic training: There are no holes for light to shine through in caves on Bizorm, so they are very dark.

Here is *another* cave from the planet Bizorm. Why do you think this cave is so dark?

Teleological training: Caves on Bizorm are very dark so that animals can hide in them
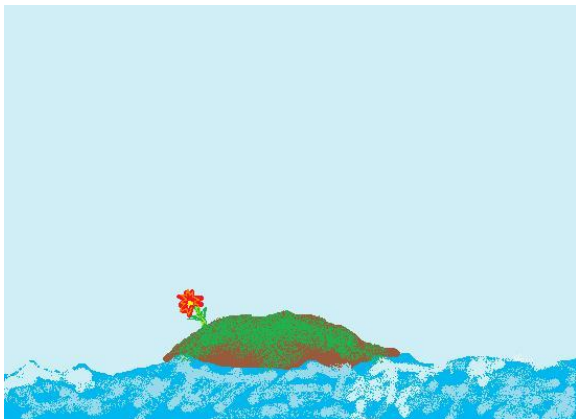
Neutral statement: Wow, look at this!
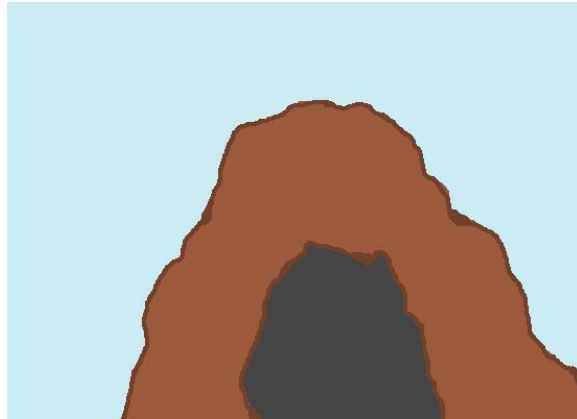
Island

Original   *Test*

Mechanistic training: Islands on Bizorm are very small because the ocean covers most of the land.

Here is *another* island from the planet Bizorm. Why do you think this island is so small?

Teleological training: Islands on Bizorm are very small so that ships don't bump into them.
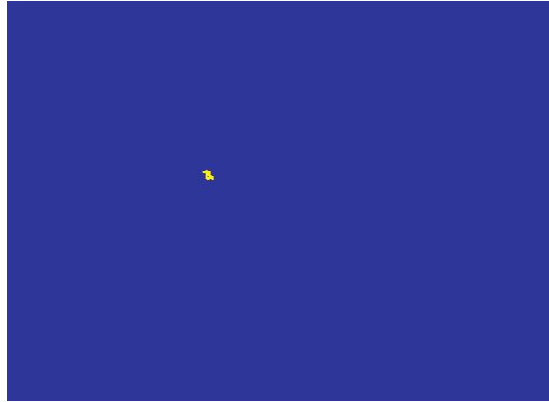
Neutral statement: Wow, look at this!

Star

Original   *Test*
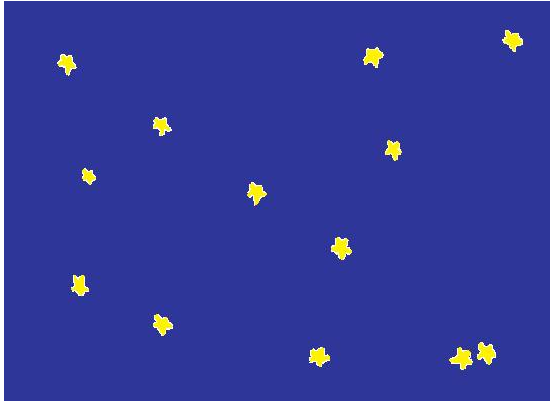
Mechanistic training: Gas burns in the stars on Bizorm, so they are very bright yellow.

Teleological training: Stars on Bizorm are very bright yellow so that people can see them.

Neutral statement: Wow, look at this!

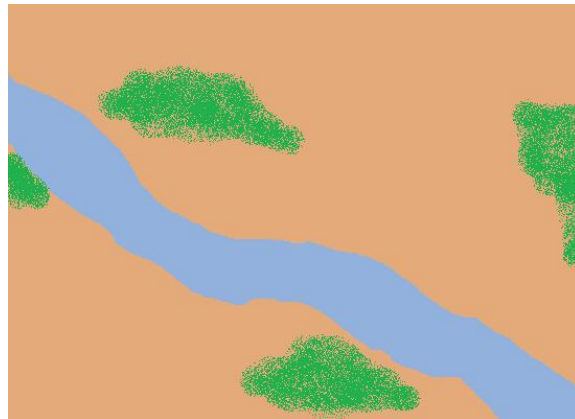Here is *another* star from the planet Bizorm. Why do you think this star is so bright yellow?

B. The five picture books used in the transfer task.

Desert

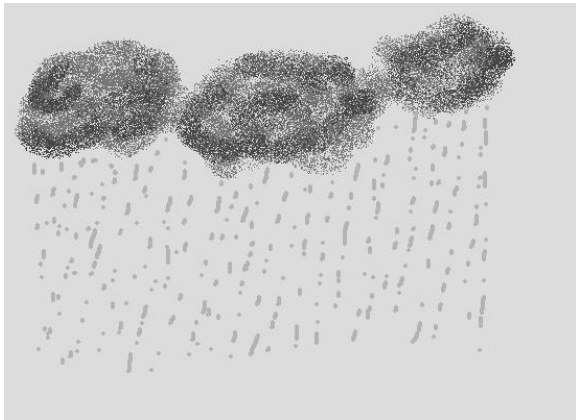"Why do you think this desert is so hot?"

River

"Why do you think this river is so narrow?"
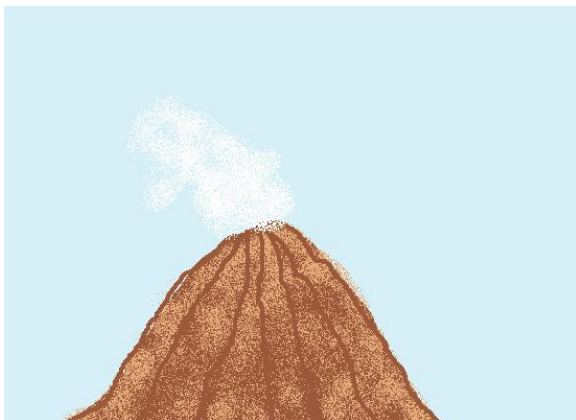
Thunder

"Why do you think this thunder is so loud?"

Canyon

"Why do you think this canyon is so deep?"

Volcano

"Why do you think this volcano has steam on top?"