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Information learned from generic language becomes central to children's biological concepts: Evidence from their open-ended explanations

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ABSTRACT

Generic sentences (e.g., "Snakes have holes in their teeth") convey that a property (e.g., having holes in one's teeth) is true of a category (e.g., snakes). We test the hypothesis that, in addition to this basic aspect of their meaning, generic sentences also imply that the information they express is more conceptually central than the information conveyed in similar non-generic sentences (e.g., "This snake has holes in his teeth"). To test this hypothesis, we elicited 4- and 5-year-old children's open-ended explanations for generic and non-generic versions of the same novel properties. Based on arguments in the categorization literature, we assumed that, relative to more peripheral properties, properties that are understood as conceptually central would be explained more often as *causes* and less often as *effects* of other features, behaviors, or processes. Two experiments confirmed the prediction that preschool-age children construe novel information learned from generics as more conceptually central than the same information learned from non-generics. Additionally, Experiment 2 suggested that the conceptual status of novel properties learned from generic sentences becomes similar to that of familiar properties that are already at the category core. These findings illustrate the power of generic language to shape children's concepts.

1. Introduction

It is a point so obvious that it is seldom, if ever, mentioned. If children did not have available to them adult instruction through language, pictures, and other symbolic media, they would know the same amount about dinosaurs as did Plato and Aristotle, namely, zero. Indeed, if human children wandered around all day on their own in solitary fashion—as do the individuals of some primate species—they would not know much more than zero about any of the topics in which their expertise is currently studied by developmental psychologists, from dinosaurs to biology to baseball to music to mathematics (Tomasello, 1999, p. 165).

Much of what children know about the world—particularly in domains that are not amenable to direct observation—is learned from others (e.g., Gelman, 2009; Harris, 2002; Harris & Koenig, 2006), and this process is typically mediated by language. The essential role of language in knowledge transmission is well illustrated by the *kind-referring generic sentence*, a linguistic structure that developmental psychologists have only recently started to explore systematically (e.g., Chambers, Graham, & Turner, 2008; Cimpian & Markman, 2008; Gelman, Coley, Rosengren, Hartman, & Pappas, 1998; Prasada, 2000). Generic sentences, or generics, express a property of an entire category (e.g., "Horses eat grass"), and this type of category–property mapping cannot be observed directly, nor can it be illustrated for someone else without the use of language (Gelman, 2004).

Generics are also quite frequent in speech to young children (Gelman, Chesnick, & Waxman, 2005; Gelman, Goetz,

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Sarnecka, & Flukes, 2008; Gelman & Tardif, 1998; Gelman, Taylor, & Nguyen, 2004; Pappas & Gelman, 1998), being produced at a rate of about 30 per hour in the context of reading picture books (Gelman, 2003; Gelman et al., 1998). In addition to being frequent, generics seem to pose few interpretive problems to children, who are able to distinguish them from non-generics on the basis of a variety of lexical, morphosyntactic, and contextual cues by the time they reach preschool (Cimpian & Markman, 2008; Gelman & Raman, 2003; Gelman, Star, & Flukes, 2002; Hollander, Gelman, & Star, 2002).

In this paper, we investigate how children actually construe the information they learn from generic and non-generic sentences. Specifically, we test the hypothesis that the information acquired from generics is understood as *deeper* or *more conceptually central* relative to information learned from non-generics (Gelman, 2004). If the features of a concept are organized in a hierarchy, with those closer to the conceptual core generating or constraining those closer to the periphery (Medin & Ortony, 1989; Murphy & Medin, 1985), then this hypothesis is equivalent to claiming that the generic/non-generic distinction can affect where in this hierarchy a new feature is embedded. For example, if children were told that "*Fish* have a bag full of air inside them", they may believe that having a bag full of air inside is an important biological property that contributes to these animals' survival by allowing them to breathe or swim. In contrast, if children heard the same novel fact in a non-generic sentence such as "*This fish* has a bag full of air inside him", they may be more inclined to construe this feature as peripheral or accidental (e.g., he must have swallowed too much air).

1.1. Previous research

One important difference in how children think about new facts learned in generic vs. non-generic form has already been documented: Relative to non-generic sentences, generics establish a stronger link between the relevant categories and properties, such that children are more likely to (a) *generalize* generically conveyed properties to novel, even atypical, members of the category (Chambers et al., 2008; Gelman et al., 2002) and (b) *classify* novel objects as belonging in the category on the basis of generically conveyed properties (Hollander, Gelman, & Raman, 2009). To illustrate, Gelman et al. (2002) have shown that 4-year-old children generalize a novel property (e.g., having a sticky tongue) to more instances of a category (e.g., bird) if this property is provided in generic format (e.g., "Birds have a very sticky tongue") than in non-generic indefinite format (e.g., "Some birds have a sticky tongue"; see also Chambers et al., 2008). Not only is a property learned from a generic sentence thought to apply to more category members, but it also becomes a more valid cue (e.g., Rosch & Mervis, 1975) to whether an unfamiliar object is an instance of the category. Hollander et al. (2009) showed 4- and 5-year-old children an instance of a novel animal kind, labeled it with a novel noun (e.g., "a bant"), and highlighted one of its properties either in generic ("Bants have stripes") or in non-generic ("This bant has stripes") form. When asked to decide which of two test items was also a bant, children chose the items that shared the original object's highlighted feature (e.g., the stripes) more often on the generic trials than on the non-generic trials, despite the presence of a salient same-shape alternative (e.g., Landau, Smith, & Jones, 1988) on both types of trials. Thus, presentation in a generic frame boosts a property's validity as a cue to membership in the category.

Although these studies demonstrate the ability of generic language to convey the strength of the association between a property and a category, they leave open the possibility that what generics convey to children can be reduced to a statistical association. Such a factual or statistical connection (Prasada & Dillingham, 2006, 2009) between the category and the property could well produce these results: For example, "Bants have stripes" (but not "This bant has stripes") could lead to the inference that most, or even all, bants have stripes, which could then cause a child to assume that even bants they have not seen before are striped and to exclude any animals without stripes from this category. The main goal of this paper is to provide evidence that the differences in how children think about information learned from generic vs. non-generic sentences do *not* in fact reduce to differences in implied feature frequency. Hearing a property phrased generically leads children to construe it as being more conceptually central than hearing it phrased non-generically—and this is an inference that goes beyond simply thinking that this feature is more prevalent (e.g., Ahn, 1998; Medin & Shoben, 1988).

1.2. Our argument

1.2.1. Open-ended explanations as a dependent measure

To assess how children represented the generic and non-generic information provided, we elicited their spontaneous explanations. In doing so, we assumed that we would be tapping into a process of interpretation and theory-building that children engage in routinely (e.g., Ahn, Gelman, Amsterlaw, Hohenstein, & Kalish, 2000; Carey, 1985; Gelman & Koenig, 2003; Gopnik, 1998; Gopnik, Meltzoff, & Kuhl, 2001; Keil, 1989; Lombrozo, 2006). On this view, children are thought to learn about the world much as a scientist would, generating evidence and interpreting their observations in light of previously held causal-explanatory theories. Children seek to *understand* and *explain* what they learn. New information about an object is not simply added to a static feature list but rather is actively integrated with prior knowledge about that object—about how it behaves, what it needs, where it is usually found, etc. For example, if children learned that fish have a bag full of air inside them, they may try to make sense of this feature in light of what else they know about fish (e.g., they live under water, breathe under water, swim) and may thus link it to one or more of the features already represented in the concept (e.g., the bag is for breathing under water). We assumed that eliciting children's explanations would provide us with a "readout" of this basic cognitive process, which we could in turn use to determine the new features' relative centrality.

1.2.2. Assessing conceptual centrality through explanations

What types of explanations signal that a piece of information was construed as conceptually central? To answer this question, we relied on a compelling and well worked-out account of conceptual centrality—the causal status hypothesis (Ahn, 1998; Ahn, Gelman, et al., 2000; Ahn, Kim, Lassaline, & Dennis, 2000; Ahn & Luhmann, 2004; Hadjichristidis, Sloman, Stevenson, & Over, 2004; Sloman, Love, & Ahn, 1998). The core claim of this theory is that the *causal status* of a feature determines its *conceptual status*: A feature is central to a concept to the extent that other features of that concept depend on it. Or, put another way, features that are causes are more conceptually central than features that are effects. In one demonstration of this idea (Ahn, Kim, et al., 2000), adult participants were provided with three features of a novel kind of animal (e.g., "roobans" eat fruit, have sticky feet, and build nests on trees) and the causal dependence relations between them (e.g., eating fruit causes roobans' feet to be sticky, which in turn allows them to climb trees). The order of the features in this causal chain established their causal status, with the first cause in the chain (e.g., eating fruit) being the most causally central. Then, as a measure of conceptual status, the participants had to judge whether test animals that were missing one of the three features were also roobans. The causal status of the missing feature strongly influenced people's responses, in that test animals without the first feature in the chain (e.g., eating fruit) were considered less likely to be roobans than animals without the middle feature (e.g., having sticky feet), and the ones without the last feature in the chain (e.g., building nests in trees) were judged most likely to be roobans. Children show this causal status effect as well (Ahn, Gelman, et al., 2000).

In light of Ahn and colleagues' results, we assumed that the causal status of a feature drives its conceptual status. Assuming this relationship enabled us to draw conclusions about a feature's conceptual status by measuring its causal status. In other words, our strategy in this paper was to (1) analyze children's open-ended explanations in order to determine the causal status of the novel features and (2) use this information, in conjunction with the assumption above, to make inferences about these features' conceptual status. Specifically, novel features explained by appeal to things *they cause*, which are thus *causally* central, were assumed to also be more *conceptually* central than features explained by appeal to things that *caused them*. For example, saying that a fish has a bag full of air inside because it allows the fish to swim or breathe (a feature-as-cause explanation) was taken to indicate a more conceptually central construal of this feature than saying that the bag was caused by a disease or an accident (a feature-as-effect explanation).

Following Ahn (1998) and Ahn, Kim, et al. (2000), we adopted a fairly broad definition of what counts as a *causal* relation, allowing it to encompass a range of dependence relations. For example, any explanation that mentioned what the feature enables, allows, or helps, or what it is for, was placed in the feature-as-*cause* category (e.g., the bag full of air is for swimming). Note, however, that the extent to which these teleological explanations are in fact causal is a matter of debate (see Lombrozo, 2009; Lombrozo & Carey, 2006; Prasada & Dillingham, 2006, 2009). We will return to this issue in Section 4.

1.2.3. Prediction

The main hypothesis of this paper is that information introduced via generic language becomes more conceptually central than information introduced via non-generic language. The assumption that causal status (as measured from children's explanations) can be used as a proxy for conceptual status enables us to make the following prediction: Children should provide more feature-as-cause explanations and fewer feature-as-effect explanations when the novel features are presented in generic format than when they are presented in non-generic format. This pattern of results would indicate that children find the information they learn through generics to be more causally, and thus conceptually, central.

2. Experiment 1

This study is a first test of the hypothesis that the generic/non-generic distinction shapes how children conceptualize newly learned information. We provided preschool-aged children with novel properties in either generic or non-generic sentences and subsequently elicited their explanations, expecting to find that children use more feature-as-cause explanations and fewer feature-as-effect explanations for the properties they hear in generic format.

2.1. Method

2.1.1. Participants

Forty-eight 4- and 5-year-old children (24 girls; mean age = 4 years 8 months; range = 4 years to 5 years 7 months) from a university-affiliated preschool participated in this study. One additional child was tested but not included in the final sample because she could not complete the task. Children came from predominantly middle- and upper–middle-class families.

2.1.2. Materials and design

We used six pairs of sentences, each consisting of a generic and a non-generic version of the same novel property (see Table 1 for full list). Children heard either all generic sentences or all non-generic sentences—that is, generic/non-generic format was manipulated between subjects. The order of the sentences was counterbalanced across participants. Each property was accompanied by a 15 cm $\times$ 20 cm color photograph of an object from the target category (e.g., a fish, a snake). A stuffed animal was used to motivate children to provide explanations for the properties.

2.1.3. Procedure

Children were tested individually in a quiet room in their preschool. The experimenter first introduced a stuffed animal to the children and told them that the toy was "trying to figure some things out" and that they should

Table 1
Items used in Experiment 1.

Fish have a bag full of air inside them He has a bag full of air inside him
Butterflies have dust on their wings She has dust on her wings
Dolphins have a lot of fat under their skin She has a lot of fat under her skin
Trees have tubes inside them It has tubes inside it
Snakes have holes in their teeth He has holes in his teeth
Camels have lots of hair in their ears He has lots of hair in his ears

try to help it. The experimenter then brought out the picture for the first trial and asked the children to name the object in it. The experimenter provided the correct label if children said they did not know or if they named the object incorrectly. Next, the experimenter provided the relevant property, repeating it once—for example, "Wanna know something interesting about snakes? Snakes have holes in their teeth. They have holes in their teeth" (generic) or "Wanna know something interesting about this snake? He has holes in his teeth. He has holes in his teeth" (non-generic). The experimenter then asked children to explain the property—for example, "Why do you think that is? Why do snakes have holes in their teeth?" (generic) or "Why do you think that is? Why does this snake have holes in his teeth?" (non-generic). If children said they did not know, the experimenter asked them to make a guess to help the stuffed animal. If this attempt was unsuccessful, the experimenter put the picture aside and came back to it at the end of the experimental session. This script was followed for all six trials.

The experimenter had to return to an item at the end of the session on only 6.5% of trials, which suggests that the task did not pose a challenge to our young participants. When comparing the two wording conditions, we found that children seemed to have a harder time explaining the non-generic versions of our items (10.9% returns) than the generic versions (only 2.2% returns). Note, however, that the generic/non-generic difference in the frequency of returns was considerably smaller in Experiment 2 and may thus be peculiar to the current set of properties.

At the end of the session, children were thanked for their participation and led back to their classrooms. The experimenter transcribed children's responses as they were given, but the sessions were also videotaped. Videotapes are available for 46 of the 48 children in this study. These recordings were used to obtain a more complete transcription of children's responses.

2.1.4. Coding

Given our argument, the two main categories of explanations we coded for were *feature-as-cause* explanations and *feature-as-effect* explanations. These two categories accounted for over 93% of children's responses. An explanation was coded as *feature-as-cause* if it mentioned another feature, behavior, or process that the to-be-explained property enabled (e.g., snakes have holes in their teeth "so they can hold the food in their tooth" or "to drink the blood out of predators"). Note that all of these feature-as-cause explanations were teleological in nature (Keil, 1992; Kelemen, 1999; Lombrozo, 2006, 2009; Lombrozo & Carey, 2006), in that they explained the existence of a present feature in terms of its future effects—the animal has feature *X* in order to do *Y*, so it can have *Y*, because that helps it do *Y*, because that's how it gets *Y*, etc.

The second main coding category consisted of *feature-as-effect* explanations, which invoked a prior event, feature, behavior, or process as a cause for the to-be-explained property (e.g., a snake has holes in its teeth because "maybe yesterday he got poked in his teeth" or "because he doesn't brush his teeth"). Our coding of this category was sensitive only to the direction of causation and not to the actual causal mechanism invoked. As long as the property was explained as an effect of some prior cause, it did not matter whether the mechanism invoked was a clear biological or physical process (e.g., a butterfly has dust on its wings "because another animal kicked dust on her wings") or a more opaque one (e.g., a dolphin has a lot of fat under its skin "because she's so little").

Table 2 contains additional examples of these two main types of explanations. Responses that did not fit into these two categories were coded as "other"; this category included "don't know" responses as well. "Other" responses were infrequent and did not show any condition differences, so we will not discuss them further.

To prevent bias in coding, we (a) removed information about the generic vs. non-generic wording of the properties and accompanying questions and (b) pooled all subjects' explanations and randomized their order. For each trial, a coder assigned a 1 to the explanation category that best fit that response and a 0 to the other categories. If a participant provided multiple responses from the same category on a single trial (a rare occurrence), that category was still assigned a 1. That is, we coded for the presence or absence of a type of explanation on a trial, rather than for the frequency of that type of explanation. However, if a participant provided multiple explanations of different types, all the explanation categories that were represented on that trial received a 1. Only one trial out of the entire dataset for this experiment contained more than one explanation type.

To assess reliability, a second judge, who was blind to the hypotheses of the study, coded 100% of children's explanations. The agreement between the two coders was 94.4% (Cohen's $\kappa = .89$) for feature-as-cause explanations and 92.0% (Cohen's $\kappa = .84$) for feature-as-effect explanations. The disagreements were resolved by a third coder.

2.1.5. Data analysis

Each participant's responses for the feature-as-cause and feature-as-effect explanation categories were summed up across the six experimental trials; thus, the possible range for each was 0–6. These dependent variables were not normally distributed, as indicated by significant Shapiro–Wilk and Kolmogorov–Smirnov tests: Many children tended to provide the same type of explanation across trials, leading to a bimodal distribution with data points

Table 2
Examples of feature-as-cause and feature-as-effect explanations.

Item	Explanation
Feature-as-cause explanations	
Fish-bag full of air inside	So they do not die; if they are not in the water, they do not have that, so they die
	To breathe underwater
	To keep him floating. All fish have bags for floating
Butterfly-dust on wings	Maybe to protect the wings
	So she can fly
	To help them flap their wings. And to help them fly
Dolphin-fat under skin	To help them swim
	So they can be smooth on the sand under the water
	'Cause they dive deep, and deep is cold, and it's warm with big bellies
Tree-tubes inside	So they can be really tall
	So they can drink
	So they can live—just like we have bones
Snake-holes in teeth	To smell
	So they can swallow things
	So they can chew food better
Camel-hair in ears	So bugs do not get in their ears
	So the ears do not get hurt
	Maybe they have hair on their ears so they can keep their ears warm
Feature-as-effect explanations	
Fish-bag full of air inside	I think he ate a bag full of air
	Maybe 'cause a person put it in there
	A hole in the fish, and the bag falled inside the hole
Butterfly-dust on wings	Maybe she went through a big cloud of dust
	Maybe because another animal kicked dust on her wings
	'Cause she fell in some dirt
Dolphin-fat under skin	'Cause she ate a lot of fish
	Probably because it probably ate too much food
	Because she's so little
Tree-tubes inside	Maybe because there's a hole under it, and someone sticked a tube inside
	Maybe 'cause it's just fake
	Probably because a person cut a tree in half and probably put tubes inside them and then put it back together. And probably they did it a long time ago
Snake-holes in teeth	Maybe because a bug came in its room, and it bited his teeth
	'Cause he has cavities
	Maybe it's because it eats so much little stuff
Camel-hair in ears	His hair from his head went into his ears
	Because he does not check his ears
	Maybe 'cause they were cutting some hair off him and putting it in his ears

clustered around 0 and 6. In addition, the data did not display homogeneity of variance across the generic and non-generic conditions, as indicated by significant Levene's tests. Since the basic ANOVA assumptions were violated, we used ordinal logistic regressions (OLRs) to test our hypotheses. This type of analysis has the important advantage of assuming neither normality nor homoscedasticity (e.g., Fox, 1997; Howell, 2009). The OLRs were computed with the Generalized Estimating Equations procedure in the SPSS 16.0 Advanced Models module, which outputs Wald χ^2 tests of significance for all main effects and interactions (similar to the *F* tests in an ANOVA output). Where needed, non-parametric follow-up tests (e.g., Wilcoxon signed ranks tests) were used to supplement these statistics. The same analytic strategy was used in Experiment 2.

2.2. Results and discussion[1]

We hypothesized that hearing a novel piece of information in a generic sentence (e.g., "Trees have tubes inside them") would lead children to construe it as more conceptually central than if they had heard the same information in a non-generic sentence (e.g., "This tree has tubes inside it"). Based on the assumption that conceptual and causal centrality are tightly linked (e.g., Ahn, Kim, et al., 2000), this hypothesis was translated into the prediction that children in the generic condition would produce more feature-as-cause explanations and fewer feature-as-effect explanations than children in the non-generic condition.

2.2.1. Feature-as-cause explanations

To test this hypothesis, we first performed an OLR on the number of feature-as-cause explanations provided over the six trials. The predictors in this OLR were wording condition (generic vs. non-generic; between subjects) and gender (boys vs. girls; between subjects).

Confirming our prediction, children produced more feature-as-cause explanations in the generic condition ($M = 3.58$) than in the non-generic condition ($M = 2.04$), Wald $\chi^2 = 5.84$, df = 1, $p = .016$ (see Fig. 1). To illustrate, children who were told that trees have tubes inside them were more likely to talk about what this anatomical feature allows or enables (e.g., propping them up, drinking

[1] All the analyses reported here and in Experiment 2 were also performed with ANOVAs and *t* tests. The results remained substantively unchanged.

water; see Table 2) than children who heard that a particular tree has tubes inside it. No other effects were significant in this analysis.

2.2.2. Feature-as-effect explanations

A second OLR with the same two factors (wording condition and gender) was performed on the number of feature-as-effect explanations provided over the six trials. It is appropriate to analyze both the feature-as-cause and the feature-as-effect explanations because they are not redundant; that is, on any single trial, children were free to produce tokens of *neither* or *both* of these explanation types, so knowing the distribution of one type does not automatically specify the distribution of the other (as it would, for example, in the case of a two-alternative forced-choice task).

As predicted, children produced more feature-as-effect explanations in the *non*-generic condition ($M = 3.38$) than in the generic condition ($M = 2.21$), Wald $\chi^2 = 4.48$, df = 1, $p = .034$ (see Fig. 1). For example, children who heard that a particular tree has tubes inside it were more likely to explain this feature as an effect of a prior cause (e.g., somebody cut it open and put the tubes in there; see Table 2) than children who heard the generic version of this fact. No other effects were significant in this analysis.

2.2.3. Conclusion

Both of our measures supported the main predictions of the study. Children produced more feature-as-cause explanations and fewer feature-as-effect explanations when they were presented with novel information in generic sentences than when the same information was conveyed non-generically, which suggests that information learned from generic sentences acquires a more central conceptual status.

In the next study, we sought to replicate this effect with different stimuli, but we also asked an additional question: How does the conceptual status of a new property learned from a generic sentence (e.g., "Trees have *foliage* on them") compare to the status of *familiar* properties that are likely to already be central in children's representation of the concept (e.g., having leaves)? Can the newly learned information become as central as these other features? To answer this question, in Experiment 2 we compared children's explanations for familiar and novel properties in generic and non-generic formats, again using the number of feature-as-cause and feature-as-effect explanations as measures of causal, and thus conceptual, centrality.

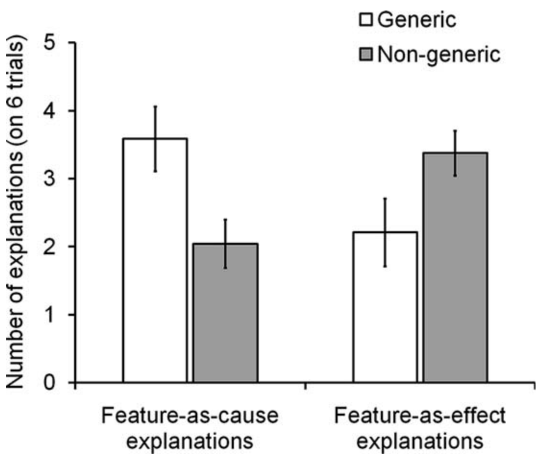

Fig. 1. The number of feature-as-cause and feature-as-effect explanations by generic vs. non-generic format in Experiment 1. The error bars represent the standard error of the mean.

3. Experiment 2

3.1. Method

3.1.1. Participants

Forty-eight 4-year-old children (24 girls; mean age = 4 years 5 months; range = 3 years 10 months to 4 years 11 months) from a university-affiliated preschool participated in this study. Six additional children were tested but not included in the final sample because they could not complete the task ($n = 2$) or because of experimenter

Table 3
Items used in Experiment 2.

Familiar properties	Novel/less familiar properties
Novel word condition	
Spiders catch flies	Spiders catch hexapods
This spider catches flies	This spider catches hexapods
Frogs live near water	Frogs live near H_2O
This frog lives near water	This frog lives near H_2O
Dogs chase cats	Dogs chase felines
This dog chases cats	This dog chases felines
Apples have seeds inside	Apples have ovules inside
This apple has seeds inside	This apple has ovules inside
Trees have leaves on them	Trees have foliage on them
This tree has leaves on it	This tree has foliage on it
Rabbits have claws on their fingers	Rabbits have talons on their fingers
This rabbit has claws on his fingers	This rabbit has talons on his fingers
Horses eat grass	Horses eat fodder
This horse eats grass	This horse eats fodder
Camels stock up food in their humps	Camels stock up nourishment in their humps
This camel stocks up food in his humps	This camel stocks up nourishment in his humps
Additional modifier condition	
Trees have roots	Trees have really deep roots
This tree has roots	This tree has really deep roots
Bears have fur	Bears have really thick fur
This bear has fur	This bear has really thick fur
Cucumbers have seeds	Cucumbers have a whole lot of seeds
This cucumber has seeds	This cucumber has a whole lot of seeds
Kangaroos jump	Kangaroos jump really, really high
This kangaroo jumps	This kangaroo jumps really, really high
Dogs bark	Dogs bark really loudly
This dog barks	This dog barks really loudly
Cats meow	Cats meow pretty quietly
This cat meows	This cat meows pretty quietly
Spiders make webs	Spiders make very thin webs
This spider makes webs	This spider makes very thin webs
Birds fly	Birds fly very high up in the sky
This bird flies	This bird flies very high up in the sky

error ($n = 4$). Children came from predominantly middle- and upper–middle-class families. None of the children had participated in Experiment 1.

3.1.2. Materials and design

Since this experiment involves a comparison of children's explanations for novel and familiar properties, we wanted to keep these two types of properties as similar in content as possible, so as to minimize confounds. We generated two sets of items that satisfied this goal. These two sets of items were used in two separate between-subjects conditions to which the 48 children were randomly assigned ($n = 24$ in each condition).

For the *novel word* condition, we generated novel versions of eight familiar properties by replacing a familiar word with one children were unlikely to know (e.g., "Frogs live near *water*" [familiar] vs. "Frogs live near H_2O" [novel]; see Table 3 for full list). A child heard either the familiar or the novel version of each property (but not both). There were eight trials in the task, four with familiar properties and four with novel properties. In addition, two of the four familiar properties were provided in generic format and the other two in non-generic format; likewise for the novel properties. Generic- and non-generic-format properties were presented in alternation. Novel and familiar properties also alternated across trials, except the alternation order for the first four trials (e.g., familiar, novel, familiar, novel) was reversed for the last four trials (e.g., novel, familiar, novel, familiar; see Table 4). Three variables were counterbalanced across subjects: (a) the order of the eight properties, (b) whether the property on the first trial was in generic or non-generic form, and (c) whether the property on the first trial was novel or familiar. Table 4 presents a sample sequence of eight items that were administered to a child in this condition.

For the *additional modifier* condition, we generated novel (or less familiar) versions of eight familiar properties by adding an adjective, adverb, or quantifier (e.g., "Cucumbers have seeds" [familiar] vs. "Cucumbers have *a whole lot of* seeds" [novel]; see Table 3). This condition was designed to introduce novelty without actually using novel words; this alternative strategy might make it easier for children to understand and explain the novel properties. In using this method of introducing novelty, we assumed that children would be less likely to know the detailed claims conveyed by using the modifiers (e.g., that cucumbers have *a whole lot of* seeds or that bears have *really thick* fur). Also note that such modified expressions are an important means of differentiating between kinds (e.g., a mango has one seed, but a cucumber has a whole lot of seeds). Aside from the items used, the additional modifier and the novel word conditions were identical.

As in the previous experiment, we used realistic color photographs of objects from the target categories (e.g., a frog). A stuffed animal was again used to motivate children to provide explanations for the properties.

3.1.3. Procedure

The procedure was almost identical to that of Experiment 1. A slight difference concerned the way the non-generic properties were presented: Instead of using personal pronouns (e.g., "he", "she", "it"), the experimenter used a demonstrative noun phrase—for example, "This cucumber has a whole lot of seeds". Including the category name in both the generic and the non-generic sentences (e.g., "Cucumbers ..." vs. "This cucumber ...") increased the overall similarity between them, allowing a stronger test of our hypothesis.

As in Experiment 1, we coded how often the experimenter had to return to an item at the end of the session because the children had been unable to provide an answer when first asked to explain it. The frequency of these returns was very low—overall, only 4.2% of trials required them—and did not vary much by condition ($M_{\text{novel word}} = 3.6\%$ vs. $M_{\text{additional modifier}} = 4.7\%$ returns), by the item format ($M_{\text{generic}} = 3.1\%$ vs. $M_{\text{non-generic}} = 5.2\%$ returns), or by property novelty ($M_{\text{familiar}} = 2.6\%$ vs. $M_{\text{novel}} = 5.7\%$ returns). Again, these data suggest that children did not find it very difficult to generate explanations for our items.

3.1.4. Coding

The coding scheme was identical to that of Experiment 1. To assess reliability, a second coder, who was blind to the hypotheses of the study, judged 90% of children's explanations. The agreement between the two coders was 98.5% (Cohen's $\kappa = .97$) for feature-as-cause explanations and 95.9% (Cohen's $\kappa = .92$) for feature-as-effect explanations. The disagreements were resolved by a third coder.

3.2. Results and discussion

3.2.1. Feature-as-cause explanations

We first performed a repeated-measures ordinal logistic regression (RM-OLR) on the number of feature-as-cause explanations. The predictor variables were (1) type of

Table 4
Sample item sequences in Experiment 2.

Trial	Familiar or novel?	Generic or non-generic?	Novel word condition	Additional modifier condition
1	Familiar	Generic	Dogs chase cats	Cucumbers have seeds
2	Novel	Non-generic	This tree has *foliage* on it	This bird flies *very high up in the sky*
3	Familiar	Generic	Frogs live near water	Spiders make webs
4	Novel	Non-generic	This horse eats *fodder*	This cat meows *pretty quietly*
5	Novel	Generic	Rabbits have *talons* on their fingers	Dogs bark *really loudly*
6	Familiar	Non-generic	This spider catches flies	This bear has fur
7	Novel	Generic	Apples have *ovules* inside	Kangaroos jump *really*, *really high*
8	Familiar	Non-generic	This camel stocks up food in his humps	This tree has roots

Note: The novel words and additional modifiers in the novel items are in italics.

wording (generic vs. non-generic; within subject), (2) familiarity (familiar vs. novel; within subject), (3) condition (novel word vs. additional modifier; between subjects), and (4) gender (boys vs. girls; between subjects).

Children produced significantly more feature-as-cause explanations when presented with generic rather than non-generic sentences ($M_{\text{generic}} = 2.02$ vs. $M_{\text{non-generic}} = 1.60$ on four trials, Wald $\chi^2 = 7.62$, df = 1, $p = .006$) and with familiar rather than novel properties ($M_{\text{familiar}} = 2.04$ vs. $M_{\text{novel}} = 1.58$ on four trials, Wald $\chi^2 = 6.36$, df = 1, $p = .012$). Evidence for the main prediction of this experiment, though, was provided by the significant wording × familiarity interaction, Wald $\chi^2 = 6.71$, df = 1, $p = .010$ (see Fig. 2, top). When explaining *novel* properties, children were significantly more likely to invoke enabling, feature-as-cause relations if the properties were phrased generically (e.g., "Trees have foliage on them") than if they were phrased non-generically (e.g., "This tree has foliage on it"), $M_{\text{generic}} = 1.00$ vs. $M_{\text{non-generic}} = .58$ on two trials, Wilcoxon $Z = 3.52$, $p < .001$. To illustrate, children said that trees have *foliage* on them "so they can grow better"; that apples have *ovules* inside "to grow" or "because that's what keeps the skin on"; that rabbits have *talons* "so they can hop well" or "to keep them safe"; that bears have *really thick* fur "so it can make them very, very warm and so when people pull it, it does not come off"; and that kangaroos jump *really, really high* "because it keeps them safe so other animals cannot eat it". This result replicates the finding from the first study, where we also obtained a generic vs. non-generic difference with novel properties. Returning to the wording × familiarity interaction in Experiment 2, the generic vs. non-generic format of the properties did *not* influence children's explanations for *familiar* properties (e.g., "Trees have leaves on them" vs. "This tree has leaves on it"), $M_{\text{generic}} = 1.02$ vs. $M_{\text{non-generic}} = 1.02$ on two trials, Wilcoxon $Z = .03$, $p = .979$. It seems that children disregarded the explicit generic/non-generic wording when they knew that the properties were true of the relevant categories. For example, even if we told children about "this tree" having leaves, they may have in fact explained their knowledge that trees in general have leaves.

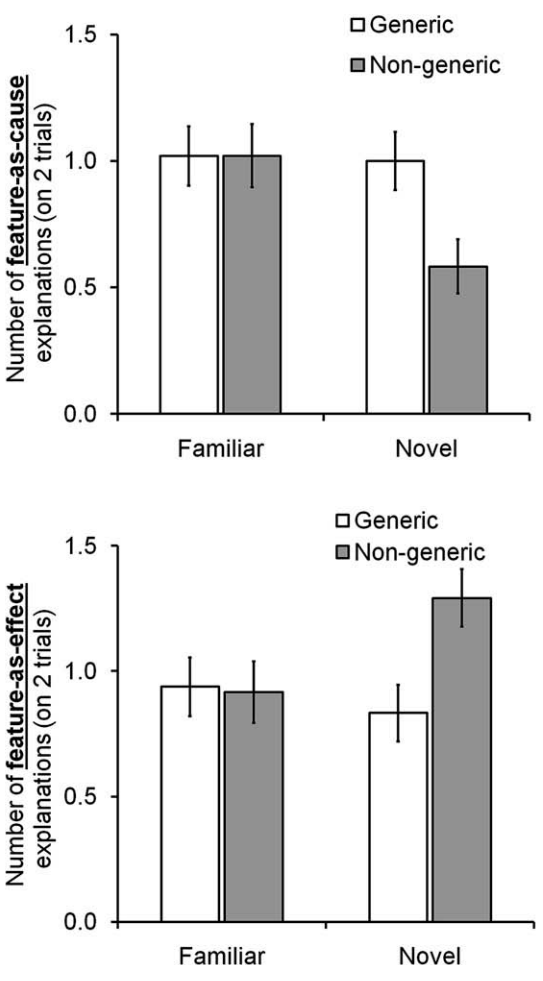

Fig. 2. The number of feature-as-cause (top) and feature-as-effect (bottom) explanations for novel and familiar properties by generic vs. non-generic format in Experiment 2. The error bars represent the standard error of the mean.

Importantly, the number of feature-as-cause explanations provided for the familiar items, both generic and non-generic, was almost identical to the number provided for the novel properties in generic format ($M = 1.00$), Wilcoxon $Zs \leqslant .18$, $ps \geqslant .857$ (see Fig. 2, top). Assuming the number of feature-as-cause explanations is an indication of conceptual centrality, this result suggests that novel properties conveyed in a generic sentence may become as central to the structure of a category as properties that are (presumably) already at the conceptual core.

The RM-OLR also revealed an unexpected main effect of condition, with children in the novel word condition providing significantly more feature-as-cause explanations overall ($M = 4.58$ on eight trials) than children in the additional modifier condition ($M = 2.67$ on eight trials), Wald $\chi^2 = 8.95$, df = 1, $p = .003$. Most likely, this effect is a byproduct of using different item sets in the two conditions; the specific reasons for it are unclear. It is important to note, however, that the three-way interaction between condition, wording, and familiarity was not significant, Wald $\chi^2 = .25$, df = 1, $p = .614$, meaning that the predicted wording × familiarity interaction was not different across the two ways of introducing novelty (additional modifier vs. novel noun).

3.2.2. Feature-as-effect explanations

Next, we performed a RM-OLR on the number of feature-as-effect explanations, using the same four predictors as above. Children produced more of these explanations when they heard non-generic sentences ($M_{\text{non-generic}} = 2.21$ vs. $M_{\text{generic}} = 1.77$ on four trials), Wald $\chi^2 = 6.27$, df = 1, $p = .012$), but this main effect was qualified by the predicted wording × familiarity interaction (see Fig. 2, bottom), Wald $\chi^2 = 9.14$, df = 1, $p = .003$: *Novel* properties conveyed in non-generic sentences (e.g., "This tree has foliage on it") were explained as effects of prior causes (features, events, etc.) more often than the same properties in generic sentences (e.g., "Trees have foliage on them"), $M_{\text{non-generic}} = 1.29$ vs. $M_{\text{generic}} = .83$ on two trials, Wilcoxon $Z = 3.46$, $p = .001$. To illustrate, children said that the apple they saw has *ovules* inside "because it's poisonous"; that the rabbit has *talons* "because it has lots of hair on its body"; that the spider catches *hexapods* "because he made a spider web"; that the bird flies *very high up in the sky* "because it has wings"; that the cat meows *pretty quietly* "because the house is quiet"; and that the kangaroo jumps *really, really high* "because it has big, long legs". Again, this difference replicates the one obtained in Experiment 1. For *familiar* properties, though, children generated the same numbers of feature-as-effect explanations regardless of the format in which properties were provided (e.g., "This tree has leaves on it" vs. "Trees have leaves on them"), $M_{\text{non-generic}} = .92$ vs. $M_{\text{generic}} = .94$ on two trials, Wilcoxon $Z = .20$, $p = .838$. Children probably realized that these properties are true of the category whether or not they were explicitly phrased as such, and their explanations reflected this understanding.

Pertinent to the main question of this experiment, the number of feature-as-effect explanations for novel properties in generic format was comparable to that for the familiar properties, both generic and non-generic, Wilcoxon $Zs \leqslant .82$, $ps \geqslant .410$ (see Fig. 2, bottom). This result again hints at the fact that the conceptual status of novel properties learned from generic sentences becomes similar to that of familiar properties.

As was the case with children's feature-as-cause explanations, the RM-OLR also revealed an unpredicted main effect of condition: Children in the novel word condition provided fewer feature-as-effect explanations overall ($M = 3.12$ on eight trials) than children in the additional modifier condition ($M = 4.82$ on eight trials), Wald $\chi^2 = 7.40$, df = 1, $p = .007$. The three-way condition × wording × familiarity interaction was not significant, however, Wald $\chi^2 = .11$, df = 1, $p = .740$, indicating that the predicted two-way wording × familiarity interaction was not different across the two conditions.

4. General discussion

The two experiments reported here support the idea that the generic/non-generic distinction has a powerful influence on how children learn new information. At one level of meaning, a generic sentence conveys that most, if not all, members of a category share a certain feature (Chambers et al., 2008; Cimpian & Markman, 2005; Gelman et al., 2002; Hollander et al., 2009). The contribution of this research is to suggest that there is an important additional layer of meaning here that even 4-year-old children are sensitive to: The information contained in a generic sentence is understood to be *of a different kind* than the information conveyed in a non-generic sentence—deeper, more conceptually central.

4.1. Logic of the argument

In these experiments, we presented children with generic and non-generic sentences containing novel information (e.g., "Snakes have holes in their teeth" vs. "He has holes in his teeth"). The hypothesis was that generic language would cause children to construe the new information as conceptually central relative to the information learned from non-generic language. To test this hypothesis, we elicited children's explanations and analyzed them to determine the causal status of the new properties. Based on Ahn and colleagues' arguments (e.g., Ahn, Kim, et al., 2000), we then assumed that the *causal* status of a property is a reliable marker of its *conceptual* status and thus that we can identify conceptually central properties by the number of feature-as-cause and feature-as-effect explanations children generate for them. Finally, we tested whether children produced more feature-as-cause and fewer feature-as-effect explanations when the novel properties were introduced via generic sentences than when they were introduced via non-generic sentences—which would suggest, given our assumptions, that generic language does indeed lead to a more conceptually central interpretation.

Another assumption underlying our logic is that children's spontaneous explanations provide an appropriate measure of causal status. Prior studies in which causal status was *measured* rather than manipulated (e.g., Ahn, 1998, Experiments 1 and 2) gave participants ample opportunity to indicate what causal relationships a certain feature entered into (e.g., by asking them to rate the plausibility of various cause–effect combinations). In contrast, we asked children a single open-ended question ("Why…?"). The choice of a simple measure low in information-processing demands was in part justified by the young age of our participants. There is also some empirical evidence that spontaneous explanations provide an accurate index of causal status (Lombrozo, 2009). Undergraduate participants were told about, e.g., a plant called "holing" that has a certain chemical compound in its stem, which causes it to bend, which in turn enables it to get pollinated by animals that pass by. After reading this story, participants were asked to provide an open-ended explanation for the middle feature (the bending stem); then, as a measure of this feature's conceptual centrality, they judged how likely it is that a plant without a bending stem is a holing. Consistent with our argument, the adults who spontaneously explained the bending as a facilitator of pollination (a feature-as-cause explanation) were more likely to rely on this feature in their subsequent classification judgments than the adults who explained the bending as an effect of the chemical compound in the stem. In fact, this study could be interpreted as showing that spontaneous explanations provide an even more sensitive index of the causal status of a feature than its position in the causal chain: Although *objectively* the causal status of the bending feature was the same for all subjects (i.e., in the middle of the three-feature causal chain), its *subjective* causal status—as revealed by each participant's feature-as-cause vs. feature-as-effect explanations—predicted the variability in this feature's conceptual status.[2]

[2] Lombrozo (2009) argues that these results actually constitute evidence *against* the causal status hypothesis because they suggest that a feature with a constant *objective* causal status can vary in conceptual status depending on how it is explained. In contrast, we believe that these findings are compatible with the causal status hypothesis if it is granted that spontaneous explanations are also a measure of causal centrality.

4.2. Summary of the results

The results of Experiment 1 confirmed our hypothesis: 4-year-old children explained novel properties in generic format (e.g., "Fish have a bag full of air inside them") more often as enabling causes (e.g., to help them swim) and less often as effects (e.g., because they swallowed too much air) than the same novel properties in non-generic format (e.g., "He has a bag full of air inside him"). Experiment 2 replicated this finding with a different set of stimuli, and, in addition, showed that children's construal of novel properties that are provided in a generic sentence (e.g., "Trees have foliage on them") is similar to their construal of familiar properties that are arguably already central (e.g., that trees have leaves). We based this conclusion on the close alignment between the content of children's explanations for familiar properties and novel properties phrased generically. That is, children provided almost identical numbers of feature-as-cause and feature-as-effect explanations across these categories of items. Thus, introducing the novel properties in generic frames seemed to compensate for their novelty and make them similar in children's minds to their better established, familiar counterparts.

Another important finding from Experiment 2 is the absence of a difference between explanations for the generic and non-generic versions of *familiar* properties—for example, children provided as many feature-as-cause explanations for, e.g., "Trees have leaves on them" as they did for "This tree has leaves on it". Presumably, when children already know that a property is true of a kind and conceptually central, they disregard the generic/non-generic frame it is provided in and explain it often in terms of its enabling functions. Thus, the generic/non-generic distinction appears to be most influential when children are reasoning about *new*, rather than familiar, information. The absence of a generic vs. non-generic effect for familiar properties also suggests that children's behavior in our experiments was driven by their interpretation of the information provided rather than by other, more superficial, differences between the generic and non-generic frames. If such surface differences (or other task demands) were responsible for the generic vs. non-generic differences in children's explanations for the novel properties, parallel differences should have emerged for the familiar properties as well.

4.3. Relationship to previous research

Previous studies found that children are more likely to generalize properties learned from generics (Chambers et al., 2008; Gelman et al., 2002) and use them to categorize new objects (Hollander et al., 2009). While these are important findings, they are open to the interpretation that generics merely strengthen the associative link between a property and a category. Our results are the first to demonstrate that the differences between children's interpretation of properties learned via generics and non-generics go beyond statistical prevalence. Hearing that a property applies to an entire kind, as opposed to a single individual, drives children to seek a different explanation for it. For instance, although prior mechanistic causes such as getting poked or bitten by a bug might explain why a particular snake has holes in its teeth, they seem inadequate as explanations for why the entire snake kind possesses this feature. To make sense of this case, children reconceptualize the feature—they switch from thinking about it as the byproduct of a specific causal chain (e.g., how did the holes get there?) to thinking about it as the causal source for other properties (e.g., what are the holes for?). This change in construal, which was assumed to also reflect a change in causal and conceptual status, suggests that the differences between information learned from generic and non-generic sentences are not limited to just statistical prevalence.

In interpreting these results as showing a change in causal centrality, we relied on the assumption that feature-as-cause and feature-as-effect explanations refer to fundamentally similar cause–effect relations that can be placed along a continuous causal chain running from the core of a concept to its periphery. (This is an assumption we share with the literature on the causal status hypothesis.) Recall, however, that all of our feature-as-cause explanations were teleological (e.g., "an animal has *X* because it enables *Y*"). Although we interpreted these explanations as indicating that *X* is a *cause* of *Y*, there is some debate about whether they are in fact causal, and, if so, what type of causal relations are involved (see Lombrozo & Carey, 2006, for discussion). Nevertheless, even if this teleological-is-causal assumption is denied, our studies demonstrate that children have systematically different construals for the properties learned from generic vs. non-generic sentences.

To our knowledge, this is the first study to demonstrate empirically a connection between generic sentences and conceptual centrality in children. In a recent article, Gelman and Bloom (2007) failed to find evidence for such a connection. Children were told a story about a set of four novel animals (e.g., dobles) that had claws either because they were born with them (intrinsic origins) or because they put them on (extrinsic origins). When subsequently asked the generic question "Do dobles have claws?", children were very likely to respond "yes"—and equally so for the vignettes in which the claws were an innate (and thus more central) feature or an acquired (and thus more peripheral) one. Adults, on the other hand, only answered "yes" when the property was innate. Thus, while for adults "generics are used to express deep (intrinsic, innate) properties that are associated with a category" (Gelman & Bloom, 2007, p. 179), the case was less clear for children, since they did not map generic meaning exclusively onto an innate property (i.e., when the dobles were born with claws). In contrast, our studies show that children are more likely to understand novel properties expressed in generic sentences as being "deeper", more conceptually central, more "essential" (Bloom, 2004; Gelman, 2003) than the same properties expressed in non-generics.

One reason for this discrepancy may be the fact that the two studies used different instantiations of the deep/superficial distinction: While Gelman and Bloom tested children's ability to map generic meaning onto *innate*, as opposed to *acquired*, properties, we tested whether they understand generic sentences to refer to *causally central*, as opposed to *causally peripheral*, properties. It is possible that children first develop an understanding of the mapping to causal depth and only later realize that properties expressed in generic sentences are also more likely to be innate. The two sets of studies also investigated different aspects of the semantics of generics: Gelman and Bloom tested children's understanding of the *truth conditions* of a generic sentence—what kinds of properties out in the world warrant being described with a generic. In contrast, our studies *provided* children with generic and non-generic sentences and tested the *implications* of these types of sentences for children's construal of the information learned. It may be that preschool-age children are still refining their understanding of when to use or accept generic sentences (especially since many generics in English do not in fact describe inherent or innate properties—e.g., "Dogs wear collars"; Prasada & Dillingham, 2006), but, when provided with such a sentence, they realize that its conceptual implications differ from those of a non-generic sentence.

Note, however, that many of our novel properties were biological in nature. Thus, it could be that children interpret novel information conveyed in generics to be conceptually central only when it is also of the right sort—when it contains reference to certain semantic elements (e.g., body parts, insides) that connect with children's lay biological theories. Conversely, it is possible that children's explanations would not be influenced by the generic/non-generic distinction if the novel properties expressed in them were accidental or temporary (e.g., being dirty; see Cimpian & Markman, 2008; Gelman, 1988), if they strongly suggested a statistical connection to the category (e.g., "Birds are kept in aviaries"; see Prasada & Dillingham, 2006), or if they had explicitly extrinsic origins (Gelman & Bloom, 2007). Exploring how the generic/non-generic distinction interacts with these different types of properties would be worthwhile, as it would demonstrate that children filter the linguistic information they receive through their theoretical knowledge (instead of accepting it indiscriminately).

4.4. Conclusion

Our findings suggest that children treat new information learned from generic language as being more conceptually central than the same information conveyed in non-generic sentences. This research adds to a growing literature documenting children's sensitivity to subtle features of the language they hear. For example, there is considerable evidence for the power of *nouns* to essentialize—to imply that a certain fact or property is central to the identity of the object described (e.g., Markman, 1989). In one study (Gelman & Heyman, 1999), 5- and 7-year-olds made stronger inferences about a person when they heard her behavior described with a novel noun (e.g., "Rose is a carrot-eater") than when the description consisted of a predicate containing very similar information (e.g., "Rose eats carrots whenever she can"; see also Heyman & Diesendruck, 2002; Markman, 1989; Semin & Fiedler, 1988; Walton & Banaji, 2004). That is, when children heard the noun, they were more likely to assume that the protagonist's preference was stable across time (e.g., Rose will eat carrots when she is grown up) and resilient to adverse circumstances (e.g., she would eat carrots even if her family tried to make her stop). Cimpian, Arce, Markman, and Dweck (2007) showed that subtle linguistic variations of this sort can also affect children's achievement motivation. They argued that children might conceptualize their abilities differently depending on whether the feedback they receive is *generic* (in that it generalizes across time and situations) or *specific* to the current behavior or outcome. For example, if children are praised with "You are a good drawer" (an individual-referring generic sentence) after succeeding on a drawing task, they may infer that their good performance is the result of a stable trait (e.g., drawing ability or talent). This inference may in turn affect children's motivation, especially when they are faced with difficulties: Mistakes may be interpreted as reflecting a low level of underlying ability and thus become especially demotivating and threatening to children's sense of self-worth. In support of this argument, when 4-year-olds' successes were praised with the generic "You are a good drawer", their responses to subsequent mistakes were significantly more negative than if their successes had been praised with "You did a good job drawing", a non-generic/specific sentence. Along the same lines, the research we described in this paper suggests that by 4 years of age children have learned that a particular linguistic construction—the kind-referring generic sentence—carries information that is conceptually central. Given the frequency of generics in child-directed speech (Gelman and Tardif, 1998; Gelman et al., 1998, 2004, 2008), this mapping may allow for substantial effects of children's linguistic environment on their reasoning about the natural and social world.

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