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Whitewashing Nature: Sanitized Depictions of Biology in Children's Books and Parent–Child Conversation

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The biological world includes many negatively valenced activities, like predation, parasitism, and disease. Do children's books cover these activities? And how do parents discuss them with their children? In a content analysis of children's nature books (Study 1), we found that negatively valenced concepts were rarely depicted across genres and reading levels. When parents encountered negative information in books (Studies 2–3), they did not omit it but rather elaborated on it, adding their own comments and questions, and their children (ages 3–11) were more likely to remember the negative information but less likely to generalize that information beyond the animal in the book. These findings suggest that early input relevant to biological competition may hamper children's developing understanding of ecology and evolution.

In the children's book *Jenny Jellyfish* (Tate, 2001), a moon jelly named Jenny drifts through the ocean with her friend Jiggly. She avoids a turtle, eats fish, meets other jellyfish, lays eggs, washes up on a beach, and is finally returned to the ocean with the help of humans. Jenny does not dry out on the beach and neither do any of her friends. She avoids being eaten by predators and so do all her babies. In the book *Opossum at Sycamore Road* (Walker, 1997), a mother possum escorts her babies through a suburban backyard. They eat insects and fruit, climb tries, hang by their tails, scavenge from a trashcan, play dead when approached by a dog, and retreat to a nest at daybreak. The opossums are not plagued by fleas or ticks; they do not compete with other opossums for food or shelter; and they do not suffer any injuries or illness.

Jenny Jellyfish and *Opossum at Sycamore Road* are marketed to parents as educational books for young readers. They include additional facts about jellyfish and opossums in an appendix, and they are illustrated with detailed depictions of the animals' habitat. The stories cover several true facts about jellyfish and opossums, but there are other facts about these animals that are not covered—facts pertaining to their daily struggle against pathogens and parasites, predators and competitors. In the real world, most organisms do not survive to reproduce, and most species go extinct (Mayr, 2001).

To understand ecology and evolution, one has to appreciate the struggle for existence inherent in biological systems (Shtulman, 2019), but some of the information about this struggle may be missing from the earliest input that children receive about the biological world. Topics like illness (Legare & Gelman, 2008), death (Slaughter & Griffiths, 2007), and extinction (Poling & Evans, 2004) are emotionally charged, and emotionally charged topics are frequently avoided in conversation or excluded from popular media (Rosengren et al., 2014). Here, we explore the representation of negatively valenced information in two sources of input central to the construction of early biological knowledge: nature books and parent–child conversation about these books. We explore not only the character of this input but also the impact it may have on children's interpretation of biological processes. Our emotional reaction to biological processes is irrelevant to their role in biological systems, but that reaction may shape whether children are exposed to such information, which, in turn, may shape the development of their folkbiology.

Many biological processes occur within the life and body of a single organism, such as digestion, circulation, metabolism, and growth. These processes can be understood within a vitalist framework for thinking about the life-sustaining

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functions of internal organs (Inagaki & Hatano, 2004) or an essentialist framework for thinking about the development and expression of species-typical traits (Gelman, 2004). Other biological processes occur at the level of the population, pertaining to relations among organisms within and across species. Such processes often entail competition. Predators compete with prey; parasites compete with hosts; diseases compete with carriers; members of the same species compete for food, shelter, and mates. Competition is an inherent property of biological systems, but many aspects of competition may be deemed unpleasant or even immoral. Such evaluations could lead adults to omit these processes when describing or discussing biological phenomena with children, and the absence of this input may wrongly imply that negatively valenced processes are absent from nature.

Research on how adults understand ecology suggests that competition does not play a central role in that understanding. Many adults believe that stable ecosystems are characterized by ample food, water, and shelter; a harmonious balance between overpopulation and extinction; a mutually beneficial relationship between organisms and their physical environment; and the capacity for all species to survive and reproduce (Zimmerman & Cuddington, 2007; see also Ergazaki & Ampatzidis, 2012).

Many adults also believe that competition is rare. When asked to estimate the frequency of various interorganism behaviors, they overestimate the frequency of cooperative behaviors, like altruism and alloparenting, and underestimate the frequency of competitive behaviors, like cuckolding and cannibalism, particularly when the target of the behavior is a member of the same species (Shtulman, 2019). Cooperative behaviors are of course important, driving biological change as much as competitive behaviors, but it's an open question whether people's emotional reaction to animal behaviors shape the frequency of their inclusion in biological discourse, particularly if that discourse is directed to young learners still attempting to discern how biological systems work and which biological processes constitute regularities as opposed to anomalies (Foster-Hanson & Rhodes, 2019). Many aspects of biological competition may elicit negative emotions, and our goal in the present research is to determine whether and how such information is included in child-directed input about the biological world.

The relevance of such input is demonstrated by research on lay conceptions of evolution, which finds that most people misunderstand evolution as a noncompetitive process. Evolution is the byproduct of differential survival and reproduction within a population; the traits possessed by the most reproductively successful individuals spread through the population over time. But most adults misunderstand evolution as the uniform transformation of an entire population, where every organism bears offspring more adapted to the environment than it was at birth (Bishop & Anderson, 1990; Kampourakis, 2014; Shtulman, 2006). Evolution is viewed as a kind of metamorphosis, with all organisms acquiring the traits they need to acquire in order to survive; selection plays no role in this process. Such views are common not only among biology novices but also those who have had extensive instruction in biology, including college biology majors (Coley & Tanner, 2015), science graduate students (Gregory & Ellis, 2009), preservice science teachers (Rice & Kaya, 2012), and high school biology teachers (Yates & Marek, 2014).

There are many reasons why adults misunderstand ecology and evolution, from underappreciating within-species variation to overascribing purpose to nature (Coley, Arenson, Xu, & Tanner, 2017; Shtulman, 2017), but an additional reason may be that nature is portrayed in ways that understate or undermine the competitive processes that drive ecological and evolutionary change. The present study explored this possibility from a developmental perspective, focusing on children's nature books and parent–child conversation about those books.

Previous research has shown that children's books are a potent source of information about biological concepts (Strouse, Nyhout, & Ganea, 2018). Preschoolers can successfully learn about camouflage (Ganea, Ma, & DeLoache, 2011), illness (Schulz, Bonawitz, & Griffiths, 2007), and natural selection (Kelemen, Emmons, Seston Schillaci, & Ganea, 2014) from storybooks. But storybooks can also seed misconceptions (Geerdts, 2016). Storybooks that include animals rarely portray the animals' habits and habitats appropriately (Marriott, 2002). Instead, they anthropomorphize the animals, which can interfere with children's ability to learn novel properties of real animals (Ganea, Canfield, Simons-Ghafari, & Chou, 2014) and their assessment of how widely those properties are shared (Waxman, Herrmann, Woodring, & Medin, 2014).

The same mixed pattern of findings has been observed in the context of parent–child conversation. While parents are accurate sources of information for some biological topics, like basic physiology (Heddy & Sinatra, 2017) and growth

(Jipson & Callanan, 2003), they can also be sources of misunderstanding, modeling nonscientific inference strategies like essentialism (Shtulman & Checa, 2012), anthropomorphism (Rigney & Callanan, 2011), and animism (Jipson, Gülgöz, & Gelman, 2016). Most parents are not biology experts, and the input they provide their children may be tainted by the same biases that pervade their own folkbiological reasoning (Shtulman, 2017).

No studies, to our knowledge, have analyzed how children's books and book-based conversations portray behavior relevant to biological competition, but several studies have explored the portrayal of death (Cox, Garrett, & Graham, 2005; Poling & Hupp, 2008; Rosengren et al., 2014). Children in industrialized societies like the United States tend not to hear much talk about death. When they do encounter such discussions, the focus is more on grieving than dying. Children's books on death typically discuss the sadness, anger, or longing felt by the deceased's loved ones but rarely discuss the biological process of death itself, as the cessation of bodily functions.

Here, we expand the scope of inquiry beyond death concepts and survey child-directed input for concepts pertaining to the struggle for existence more generally, including predation, disease, extinction, and differential survival. We hypothesized that these concepts would be rare in children's books, eclipsed by neutrally valenced information about what animals eat, where they live, what their bodies are like, and how they care for their young. Many aspects of biological competition may strike the creators of children's books as unpleasant or disturbing, leading to their omission. Biological competition is not inherently negative, but we focus on aspects that reliably elicit negative emotions in adults and explore their representation relative to more neutral concepts, from those that pertain to individual organisms (such as growth, metabolism, and internal structure) to those that pertain to noncompetitive relations among organisms (such as inheritance, biodiversity, and social structure).

Following the analysis of children's books (Study 1), we explore how parents treat negatively valenced information when discussing nature books with their children (Study 2). We hypothesized that they would selectively omit this information, particularly when conversing with younger children. This hypothesis turned out to be wrong; we find instead that parents fixate on negative information, discussing it more than neutral information with younger children and older children alike, and this discovery inspired us to investigate what children learn from book-based conversations. Parents' fixation on negative information may have the same impact as omitting that information if their comments and questions serve to mark the information as anomalous. We explore this possibility in our final study (Study 3) by asking children whether the facts they learned in the book generalize to other animals. Our hypotheses in all three studies were exploratory, with the exception of those in Study 3 intended to confirm patterns of parent–-child conversation observed in Study 2.

Study 1

The goal of Study 1 was to determine whether children's books about nature cover all aspects of nature or preferentially focus on neutral aspects over negative ones. We hypothesized that negatively valenced concepts would be underrepresented relative to other concepts entailed by a mature understanding of biology, including not only organism-level concepts but also ecological concepts that lack negative valence. We explored the frequency of these concepts across genres and reading levels, to assess whether the inclusion of negative concepts (or lack thereof) occurred with equal frequency for different types of books. Fictional books about animals may portray fewer negatively valenced concepts if their focus is on promoting responsible or prosocial behavior (Larsen, Lee, & Ganea, 2018; Walker & Lombrozo, 2017), but the reverse could be true if they are more commonly focused on teaching lessons about human frailties, as done in fables (Melson, 2001). While we explore possible differences across genres and reading levels, our primary focus was to assess whether negatively valenced concepts are represented in appropriate proportion to their neutral counterparts.

Method

Materials

We selected 381 books to code from Amazon's collection of children's nature books. This collection includes over 40,000 books, identified as such by their publisher, and we sampled this collection by focusing on the most popular books written for preschool- and elementary-school-aged children. Amazon showcases the 50 best-selling books within each of its categories, and we added all best sellers in the category of children's nature books to our shopping cart if they were written for children between the ages of four and eight (as specified by the website). We then followed Amazon's customer recommendations, adding to our shopping cart any age-appropriate book purchased by consumers who also purchased one of the top-50 books. We continued following Amazon's recommendations until all recommended books were already in our shopping cart. This sampling method provided a snapshot of the most commonly purchased nature books for preschool and elementary-school-aged audiences at the time we purchased them (January of 2011). Our sample was undoubtedly biased by customer's preferences, but the books that customers prefer are also the ones that children are most likely to encounter.

Four books initially selected for coding turned out not to contain any biological concepts and were dropped from the data set, yielding a total of 377. Details on each book can be found in Supporting Information posted to the Open Science Framework: https://osf.io/g7e8y/. Coders determined that 163 books were nonfiction, 54 were fiction, and 160 contained both fictional and nonfictional elements. The latter genre, which we term "mixed," typically followed the realistic activities of a fictitious animal, similar to *Jenny Jellyfish* and *Opossum at Sycamore Road*.

The books ranged in length from 46 words to 6337 words ($M = 1{,}205$, $SD = 1{,}136$). We quantified reading level by calculating the average number of words per page ($M = 34.6$, $SD = 29.7$). We treat reading level as a continuous variable in our analyses but break it into quartiles for the purposes of data presentation in Figure 1. Because we sampled books by popularity, rather than genre or reading level, our classifications are post hoc. Still, they provide a means of testing the generalizability of any pattern observed for the overall collection.

Procedure

Each book was analyzed for the inclusion of 32 biological concepts, displayed in Table 1. These concepts were culled from two popular high school biology textbooks: Miller and Levine's (2010) *Biology* and Campbell et al.'s (2008) *Biology*. We used high school textbooks because they provide a metric of what constitutes a mature understanding of biology for the average adult. High school biology is the most advanced biology that most adults take, so the concepts included in this curriculum provide a pedagogically vetted view of what counts as sufficient knowledge for nonexperts. The rubric derived from these textbooks was applied to all 377 books, regardless of reading level or genre.

Half the concepts pertained to the properties of individual organisms, including behavioral properties (diet, habitat, motor response), physiological properties (digestion, circulation, reproduction), and homeostatic properties (metabolism, temperature regulation, growth). We refer to these concepts as "organismal." The other half pertained to relations among organisms, including relations across species (predation, food webs, interspecific competition), relations within species (variation, inheritance, differential survival), and relations among other taxonomic units (biodiversity, extinction, common descent). We refer to these concepts as "ecological."

The ecological concepts were further divided by their emotional valence; half were deemed neutral (biodiversity, social groups, altruism, food webs, superfecundity, variation, inheritance, common descent) and half were deemed negative (predation, parasitism, extinction, disease, interspecific competition, intraspecific competition, differential survival, differential reproduction). One negative concept—death—was not included in the rubric because it was presupposed by most of the other negative concepts. In sum, the cut between organismal and ecological concepts reflects the distinction between processes occurring within and between organisms, and the cut between negative and neutral concepts reflects a distinction in people's emotional reactions to them.

We created this list of concepts by collating the chapter headings and major section headings of the reference textbooks and then eliminating redundancies through discussion, with the goal of identifying an equal number of organismal and ecological concepts, as well as an equal number of neutral and negative concepts within the latter category.

To confirm that the concepts we classified as negative are generally viewed as such, we recruited a sample of lay adults (33 college undergraduates) and asked them to rate their agreement with the statement "This concept elicits negative emotions" on a seven-point scale for each of the 36 concepts in the rubric. We then averaged their ratings by category (organismal, neutral ecological, negative ecological) and submitted them to a repeated-measures analysis of variance (ANOVA). This analysis revealed significant differences in perceived negativity among the categories ($F(2, 64) = 186$, $p < .001$, $\eta_p^2 = .85$). Post hoc comparisons with Bonferroni corrections confirmed that negative ecological concepts were viewed more negatively than neutral ecological concepts ($t = 17.53$, $p < .001$) and organismal concepts ($t = 15.79$, $p < .001$), whereas the latter two concepts were viewed equivalently

Table 1
Number of Nonfiction Books, Mixed-Genre Books, and Fiction Books That Contain Each Biological Concept; Concepts Are Ordered by Their Frequency Within Each Category

Category	Concept	Nonfiction	Mixed	Fiction	Total proportion
Organismal	Habitat	147	123	25	.78
	Diet	131	120	18	.71
	Reproduction	108	87	9	.54
	Growth	83	67	10	.42
	Motor response	64	65	8	.36
	Taxonomic classification	126	52	7	.33
	Metabolism	70	47	5	.32
	Metamorphosis	41	28	3	.19
	Internal structure	34	35	5	.16
	Thermoregulation	29	17	0	.12
	Digestion	29	12	0	.11
	Photosynthesis	19	11	2	.08
	Excretion	18	10	1	.08
	Immune response	1	3	1	.01
	Circulation	1	1	1	.01
	Genes	2	1	0	.01
Ecological: neutral	Biodiversity	69	90	28	.50
	Social groups	80	72	14	.44
	Altruism	71	58	8	.36
	Food webs	43	36	9	.23
	Variation	30	24	3	.15
	Inheritance	15	19	4	.10
	Common descent	17	11	1	.08
	Superfecundity	5	9	0	.04
Ecological: negative	Predation	130	110	17	.68
	Extinction	48	18	1	.18
	Differential survival	32	18	2	.14
	Parasitism	25	20	1	.12
	Interspecific competition	20	21	3	.12
	Intraspecific competition	20	14	4	.10
	Disease	10	2	1	.03
	Differential reproduction	5	1	0	.02

($t = 1.74$, $p = .200$). Even at the item level, every negative ecological concept was rated as more negatively valenced than any concept from the other two categories (see the Supporting Information at https://osf.io/g7e8y/).

In addition to negativity ratings, adult raters also rated the complexity of each concept on a seven-point scale. Complexity ratings did not vary by category ($F(2, 64) = 1.83$, $p = .169$, $\eta_p^2 = .05$), indicating that negative ecological concepts were not perceived as more complex than those from the other categories.

There are, however, some resemblances across categories. The organismal concept of reproduction, for instance, resembles the ecological concept of inheritance, and the neutrally valenced concept of food webs resembles the negatively valenced concept of predation. Such concepts were distinguished by their depiction within the books. Books were coded as discussing reproduction if they described the process of producing offspring but were coded as discussing inheritance if they described how offspring resemble their parents. Books were coded as discussing food webs if they described the flow of energy through an ecosystem but were coded as discussing predation if they described the act of hunting and consuming prey. Processes that overlap or interact from a biological point of view were thus distinguished by their role within the narrative context.

Coders were equipped with definitions that allowed them to identify instances of each concept (see the Supporting Information at https://osf.io/g7e8y/ for each definition). It should be noted that we classified altruism as a neutral concept, rather than a positive concept, because it was the only ecological concept with a positive valence, and we chose to group it with the neutral concepts rather than omit it from the taxonomy. It should also be noted that we coded for the presence or absence of each concept rather than the emphasis placed on that concept, as we suspected that negatively valenced concepts would be absent from most books. Our goal was to determine whether negatively valenced concepts were represented in proportion to our coding rubric, not whether they were represented in proportion to their importance or prevalence in actual biological systems.

Four independent coders (undergraduate psychology majors) read the entire collection of books. For each book, they determined whether each concept on the rubric was included or not included (a dichotomous decision). Coders then compared codes in teams of two, deriving a joint list of codes through discussion. The two coding teams then compared codes to derive a final list agreed upon by all four coders. Agreement was high at the first stage of coding (87%; Cohen's $\kappa = .74$) and even higher at the second (94%; Cohen's $\kappa = .88$).

Results

Table 1 shows how frequently different biological concepts appeared in the books. The most common organismal concepts were habitat (appearing in 78% of books), diet (71%), and reproduction (54%). Among the ecological concepts, the most common neutral concepts were biodiversity (50%), social groups (44%), and altruism (36%), and the most common negative concepts were predation (68%), extinction (18%), and differential survival (14%). Negative ecological concepts were represented less frequently than concepts in the other two categories. While about half of the nonnegative concepts appeared in at least a fifth of the books, only one negative concept met this criterion (predation).

Individual concepts appeared with similar frequency across genres, as can be seen in Table 1. Concept frequencies for nonfiction books were highly correlated with those for mixed-genre books ($r = .95$, $p < .001$); concept frequencies for mixed-genre books were highly correlated with those for fiction books ($r = .91$, $p < .001$); and concept frequencies for fiction books were highly correlated with those for nonfiction books ($r = .80$, $p < .001$).

On average, nonfiction books included 9.0 concepts ($SD = 3.7$), mixed-genre books included 7.4 ($SD = 3.2$), and fiction books included 3.5 ($SD = 2.1$). This difference was statistically significant (F (2, 374) = 58.2, $p < .001$, $\eta_p^2 = .24$), as was the relation between concept frequency and the average number of words per page ($r = .54$, $p < .001$). To control for overall differences in the amount of biological information presented, we compared concept categories across genres and reading levels by their relative frequency, calculating the proportion of each concept type (organismal, neutral ecological, and negative ecological) to total concepts per book. Mean proportions are displayed as a function of reading level in Figure 1 and as a function of genre in Figure 2.

On average, organismal concepts comprised 58% of the concepts represented in any given book ($SD = 20\%$), neutral ecological concepts comprised 26% ($SD = 18\%$), and negative ecological concepts comprised 17% ($SD = 13\%$). If each concept was represented with equal frequency, organismal concepts would comprise 50% of the total (16 of 32), neutral ecological concepts would comprise 25% (8

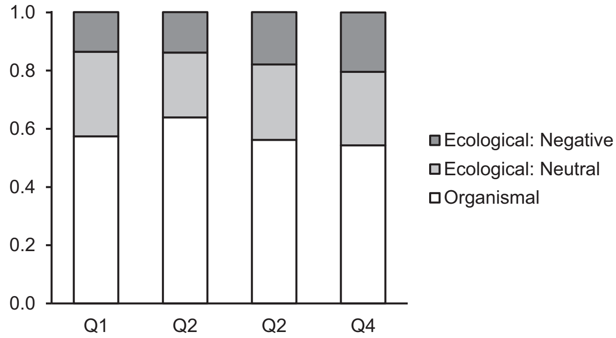

Figure 1. Mean proportion of organismal concepts, neutral ecological concepts, and negative ecological concepts within each quartile of reading difficulty.

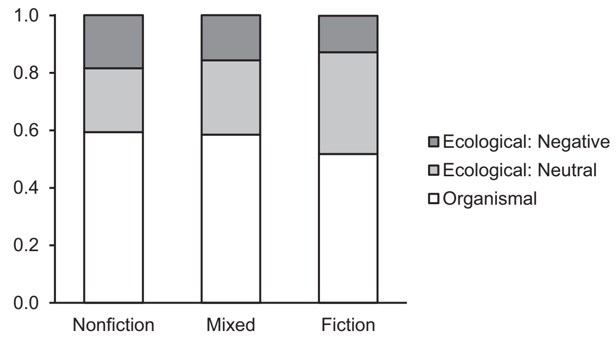

Figure 2. Mean proportion of organismal concepts, neutral ecological concepts, and negative ecological concepts within each genre.

of 32), and negative ecological concepts would comprise 25% (8 of 32). Relative to these benchmarks, organismal concepts were overrepresented in children's books ($t(376) = 7.68$, $p < .001$), and negative ecological concepts were underrepresented ($t(376) = -12.70$, $p < .001$). That is, organismal concepts were represented more than ecological ones (58% vs. 42%), with their tradeoff hinging on the negative ecological concepts; neutral ecological concepts were represented at the expected frequency.

We assessed the consistency of this pattern with a repeated-measures ANOVA, in which concept category (organismal vs. negative ecological vs. neutral ecological) was the repeated measure, genre (nonfiction vs. mixed vs. fiction) was an independent factor, and words-per-page was a covariate. This analysis revealed a main effect of concept category ($F(2, 746) = 208.42$, $p < .001$, $\eta_p^2 = .36$), as well as interactions between concept category and genre ($F(4, 746) = 7.14$, $p < .001$, $\eta_p^2 = .04$) and between concept category and words-per-page ($F(2, 746) = 9.05$, $p < .001$, $\eta_p^2 = .02$).

Follow-up analyses of variance (ANOVAs) revealed that all three concepts varied by genre (organismal: $F(2, 374) = 3.04$, $p = .049$, $\eta_p^2 = .02$; neutral ecological: $F(2, 374) = 11.70$, $p < .001$, $\eta_p^2 = .06$; negative ecological: $F(2, 374) = 4.57$, $p = .011$, $\eta_p^2 = .02$). Organismal concepts were most common in nonfiction books and least common in fiction books (linear contrast: $t = 2.42$, $p = .016$); neutral ecological concepts were most common in fiction books and least common in nonfiction books (linear contrast: $t = 4.83$, $p < .001$); and negative ecological concepts were most common in nonfiction books and least common in fiction books (linear contrast: $t = 2.85$, $p = .005$). Follow-up correlations revealed that organismal concepts decreased with the numbers of words per page ($r = -.14$, $p = .007$), neutral ecological concepts remained constant ($r = -.02$, $p = .657$), and negative ecological concepts increased ($r = .24$, $p < .001$).

These patterns indicate that the trade-off between negative ecological concepts and other types of concepts varies with genre and reading level. Negative ecological concepts decreased with the inclusion of fictional elements but increased with reading level, relative to organismal and neutral ecological concepts. Still, despite these subtle differences, negative ecological concepts were represented less than expected by our rubric in all genres (fiction: $M = 13\%$ vs. the expected 25%, $t = 5.32$, $p < .001$; mixed: $M = 16\%$, $t = 9.47$, $p < .001$; nonfiction: $M = 19\%$, $t = 7.05$, $p < .001$) and at all reading-level quartiles (quartile 1: $M = 14\%$, $t = 7.48$, $p < .001$; quartile 2: $M = 14\%$, $t = 8.85$, $p < .001$; quartile 3: $M = 18\%$, $t = 5.38$, $p < .001$; quartile 4: $M = 20\%$, $t = 3.99$, $p < .001$).

Discussion

We analyzed a large sample of the most popular children's books about nature for the inclusion of concepts deemed constitutive of a mature understanding of biology and discovered that concepts involving the properties of individual organisms were overrepresented relative to our rubric and concepts involving negatively valenced interactions among organisms were underrepresented. Only one concept of the latter type was included in a majority of books: predation. The others were included in fewer than a fifth, and some (disease, differential reproduction, intraspecific competition) were included in fewer than a tenth. Negative ecological concepts were most common in nonfiction books and books of a higher reading level, but even in these books they were still underrepresented relative to neutral ecological concepts and organismal concepts. While some organismal concepts were rare as well (genes, circulation, immune response), organismal concepts dominated the books on the whole, as many nature books focus exclusively on the habits and habitat of a single organism.

One explanation for the lack of negative ecological concepts in children's books is that authors and publishers purposely omit this information, either because they deem children ill-equipped to handle it or because they worry that parents and educators will not purchase books with negatively valenced information. Interviews with the authors and publishers of children's nature books could shed light on the intentions behind such omissions, if they are intended at all. Another explanation for the lack of negative concepts is that they are incongruent with the stories the authors intend to tell. Many stories about animals are intended to convey moral lessons (Melson, 2001), and negatively valenced information may not cohere with those lessons, especially if their purpose is to encourage prosocial behavior. Additional research is needed to determine whether the emotional valence of the concepts included in children's nature books varies with their narrative structure or purpose.

Additional research is also needed to determine whether the patterns observed here extend to books intended for older audiences (middle schoolers) or younger audiences (toddlers), as well as whether they extend to a wider range of child-directed media, including media designed mainly for entertainment purposes (television shows or movies) and media designed explicitly for educational purposes (textbooks or documentaries). Our analysis of both fiction books and nonfiction books suggests that negatively valenced concepts are rare across the board, but it's possible that texts designed for certain contexts, like middle-school classrooms, would include more negatively valenced concepts than observed in our particular sample. Analyses of such texts are an important next step, as these texts likely shape the scope and content of early biology education.

In sum, Study 1 demonstrates that negative aspects of the biological world are frequently omitted from children's books, but it's an open question how the readers of children's books might process such information. If parents deem negative biological information inappropriate for young audiences, then they should refrain from reading it to their children. We sought to test this hypothesis in the studies that follow, exploring how parents treat negative biological information when encountered in a nature book and how children react to this information.

Study 2

The goal of Study 2 was to explore the dynamics of parent–child conversation about negatively valenced biological information, as prompted by a nature book. While Study 1 found that negative concepts are underrepresented relative to neutral ones, it also found that children's nature books contain *some* negative concepts—approximately one for every four neutral concepts (ecological and organismal combined). How do parents discuss such concepts given the backdrop of mainly neutral information? We explored this question by creating a book that resembled popular children's books in its proportion of negative to neutral concepts but that presented each concept in a consistent style and format (without extraneous plotlines or morals). Parents were asked to discuss the book with their children, however, they saw fit. We hypothesized that parents would discuss the negative information less than the neutral information, particularly for younger (preschool-aged) children.

Method

Participants

Our participants were 75 parent–child groups recruited from public parks in Los Angeles County. A sample of this size was sufficient for detecting a medium-sized ($d = .5$), nondirectional difference between two dependent means (responses to negative vs. neutral information) with 98% confidence, as determined by G*Power 3 (https://www.psychologie.hhu.de/arbeitsgruppen/allgemeine-psychologie-und-arbeitspsychologie/gpower). The majority of groups ($n = 64$) consisted of one parent and one child. The rest consisted of one parent and two children ($n = 7$), one parent and three children ($n = 3$), and one parent and four children ($n = 1$). Multi-child groups were included in the analyses reported below, but our findings do not change if they are excluded. The children in our sample ranged in age from 3 to 10, with a mean age of 5.0 years ($SD =$ 2.0 years). We targeted children of this age because they were unlikely to have received much formal instruction in ecology or evolution, which are topics typically reserved for middle school and high school (National Science Teachers Association, 2013). Our wide age span was intended to maximize the opportunity for observing developmental trends in how parents broach the topic of negative biological information with their children.

Children's age was treated as a continuous variable in our analyses, but we split our groups by age for the purposes of data presentation (Figures 3–5). Groups with children under six are labeled "younger" ($n = 50$), and groups with children over six are labeled "older" ($n = 25$). We chose six as our dividing point because it roughly separates preschoolers from elementary schoolers, though none of the results hinge on this cutoff. We classified multi-child groups by the age of the youngest child because we expected that if parents censor their speech, they would do so more for younger children. That said, we did not instruct participants to tailor their behavior to their younger child, nor did we measure other factors that may have influenced the conversation, such as children's interest in animals or parents' knowledge of biology. Our goal was simply to observe whether parent–child conversations varied by the content we provided them, but future research should explore how these conversations are shaped by instructional context or participants' backgrounds.

Fifty-one percent of the children were female, and 77% of the parents were female. Preliminary analyses revealed no effects of child gender or parent gender, either in Study 2 or Study 3. Participants were not asked for their race or ethnicity, but they were sampled from a population that is 35% white, 35% Hispanic/Latino, 17% Asian, 10% black, 5% mixed race, and 1% Native American or Pacific Islander (United States Census Bureau, 2000).

Materials

Participants were provided with a book titled "Animals of the World." It contained eight animals: chimpanzees, orcas, meerkats, hippopotamuses, horned frogs, golden eagles, sea turtles, and cuckoos. These animals were selected for their taxonomic diversity, as well as their involvement in behaviors that parents might find disturbing or offensive. Animals were depicted with a photograph and described with four facts. The facts included the animal's habitat, diet, social structure, and some additional piece of information about its behavior or relation to humans. For instance, horned frogs were said to (a) occupy the wetlands of South America; (b) eat lizards, mice, and other horned frogs; (c) live by themselves; and (d) make a croak that sounds like the bellow of a cow. Meerkats were said to (a) occupy the plains of Africa; (b) eat insects, spiders, snails, and lizards; (c) live in groups of 2 to 30 individuals; and (d) wage war on neighboring meerkat colonies to expand their territory.

One of the four facts for each animal was negatively valenced, relating either to predation or aggression. The negative fact about horned frogs was that they eat other horned frogs, and the negative fact about meerkats was that they wage war on neighboring colonies. The full list of negative facts is shown in Table 2. Half pertained to the animal's diet, and half pertained to some other behavior. Preliminary analyses revealed no differences in how the two types of facts were treated, by parents or children, so we collapsed this distinction in the analyses below.

Table 2
The Negative Fact About Each Animal Presented in Studies 2 and 3

Animal	Fact
Chimps	Eat fruit, leaves, termites, red colobus monkeys
Orcas	Eat fish, squid, penguins, seals
Frogs	Eat lizards, mice, other horned frogs
Eagles	Eat small mammals, including cats and dogs
Meerkats	Will wage war on neighboring meerkat colonies to expand their territory
Hippos	Kill more people each year in Africa than any other wild animal
Turtles	Lay their eggs in holes on the beach but few babies survive the journey from beach to sea
Cuckoos	Break all other eggs in the nest when they hatch so they don't have to compete for food

Procedure

Parents were given the book of animal facts and asked to discuss the book with their child (or children) while we audio-recorded the conversation. Parents were told they could discuss each animal as much or as little as they wanted but were encouraged to cover all eight before concluding the conversation. Conversations ranged in length from 8.5 to 27.7 min, averaging 13.1 min (SD = 3.4).

Coding

For each fact, we coded whether the parent repeated it from the book or omitted it. For repeated facts, we further coded whether parents commented on it or asked a question about it. Sample comments include: "[Hippos] kill more people each year in Africa than any other wild animal. Oh my gosh. Geez. That's not nice;" "[Chimpanzees] eat fruits, leaves, termites, and red colobus monkeys. Oh, they eat monkeys. I didn't know that. Don't think about that;" and "When [cuckoos] hatch, they break all other eggs in the nest so they don't have to compete for food. Oh my goodness—I'm not sure we like them." Sample questions include: "Hippos kill more people each year in Africa than any other wild animal. So do you think they are friendly or do you think they are very rude?"; "[Chimpanzees] eat leaves, termites, red colobus monkeys. That doesn't make any sense, does it? That they will eat other monkeys?"; and "When a baby cuckoo hatches, it breaks all the other eggs in the nest so they don't have to compete for food. Can you say survival of the fittest?".

Comments and questions were coded a second time for explicitly valenced language, where the behavior at hand is characterized as bad, mean, or wrong. For example, the parent who elaborated on cuckoo behavior with the comment, "Oh my goodness—I'm not sure we like them" was coded as providing a valenced response, whereas the parent who elaborated on the same behavior with the question "Can you say survival of the fittest?" was not.

We coded whether children made comments about each fact as well. Children rarely asked questions, so we did not code questions separately as we did for parents. The few questions that children did ask comprised < 3% of their total utterances and were coded as comments. For groups involving multiple children, we focus on comments made by the youngest child, in line with our decision to analyze parent contributions by the age of their youngest child.

Two researchers independently tallied the number of parent repetitions, parent questions, parent comments, and child comments for each group and each fact. They agreed on 89% of their codes across Studies 2 and 3 (Cohen's $\kappa = .78$), and all disagreements were resolved through discussion. Because the animal-fact book contained more neutral facts than negative facts, we analyze participants' utterances by their relative frequency. That is, we divide the number of parent repetitions, parent questions, parent comments, and child comments by 8 for the negative facts (one fact for each of eight animals) and by 24 for the neutral facts (three facts for each of eight animals).

Results

The conversational patterns from the storybook task are presented in Figure 3. We submitted each measure to a repeated-measures ANOVA, in which fact type (negative vs. neutral) was the repeated measure and age of the youngest child in the group was a covariate. These analyses revealed that parents were no more likely to repeat neutral facts than negative facts ($F(1, 73) = 1.59$, $p = .211$, $\eta_p^2 = .02$), but they were more likely to comment on negative facts ($F(1, 73) = 9.05$, $p = .004$, $\eta_p^2 = .11$) and more likely to ask questions about negative facts ($F(1, 73) = 12.12$, $p < .001$, $\eta_p^2 = .14$). Children were slightly more likely to comment on negative facts than neutral facts, but this trend was not reliable ($F(1, 73) = 2.27$, $p = .136$, $\eta_p^2 = .03$).

In terms of age, parents with younger children repeated fewer facts than parents with older children ($F(1, 73) = 17.80$, $p < .001$, $\eta_p^2 = .20$), but they made more comments about the facts ($F(1, 73) = 4.23$, $p = .043$, $\eta_p^2 = .06$) and asked more questions about them as well ($F(1, 73) = 8.12$, $p = .006$, $\eta_p^2 = .10$). None of these effects were qualified by interactions between children's age and the type of fact under

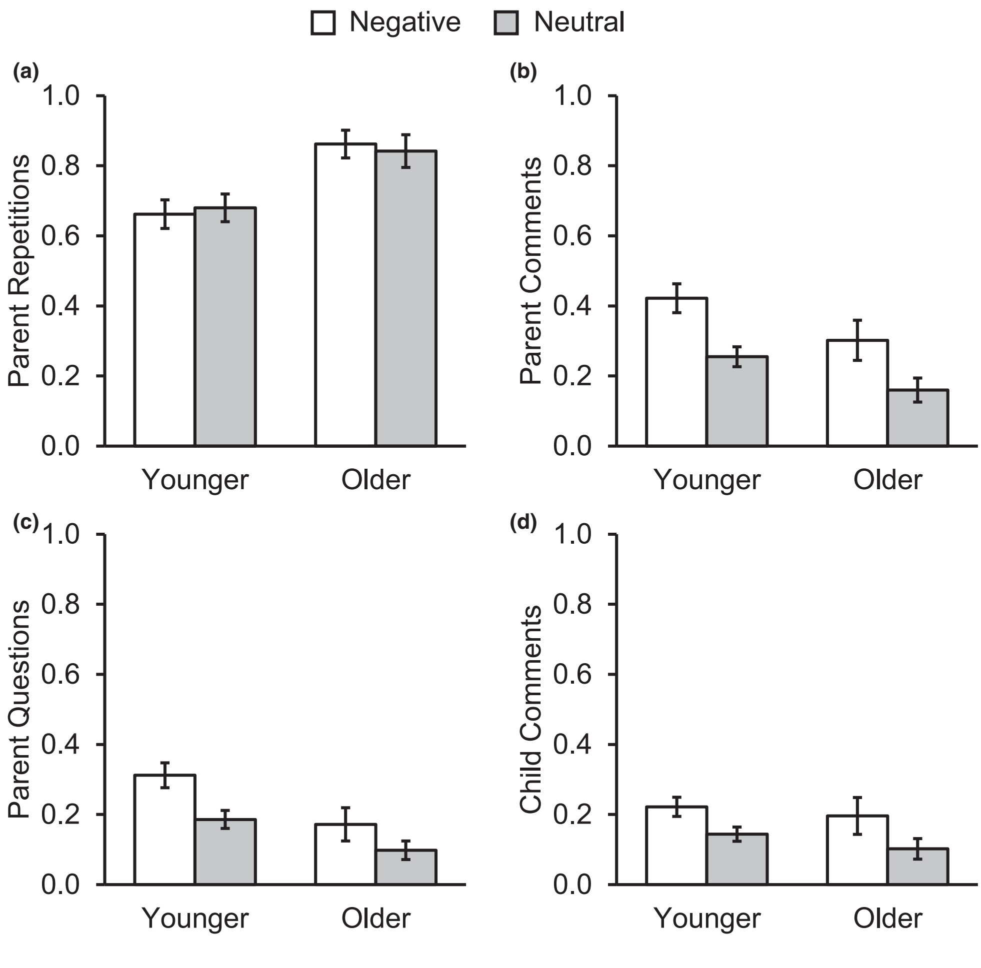

Figure 3. Mean proportion of negative and neutral facts that (a) parents repeated, (b) parents commented on, (c) parents asked questions about, and (d) children commented on, as a function of the child's age (Study 2).

consideration. In terms of valence, parents' comments and questions included more negatively valenced language for negative facts than neutral facts ($M = 11.3\%$ vs. $M = 0.4\%$; paired-samples $t = 7.05$, $p < .001$). Most parents (53%) used valenced language in reference to at least one negative fact, but few parents (11%) used this language in reference to any neutral fact ($\chi^2 = 31.37$, $p < .001$). Parents' use of valenced language was uncorrelated with their child's age ($r = -.16$, $p = .16$).

Discussion

Contrary to expectation, parents did not selectively omit negative facts when discussing biological information with their children but rather repeated negative facts as often as neutral ones. And they not only repeated negative facts but also selectively elaborated on those facts, adding their own comments and questions, often using explicitly negative language. These trends held regardless of the age of the child they were conversing with. While parents of younger children repeated fewer facts than parents of older children, they omitted negative facts no more often than neutral ones. And while parents of younger children elaborated on the facts more than parents of older children, all parents were inclined to focus on the negative facts. The consistency of this input indicates that negatively valenced concepts are flagged as distinct or special for children of all ages.

Parents' elaborations seemed to play several roles: explaining the target behavior ("sad for the seal but the orca has to eat too"), qualifying the behavior ("that's what makes it unusual"); condemning the behavior ("oh my God, that's horrible"), minimizing the behavior ("how silly"), confirming that the child was unaware of the behavior ("did you know that?"), criticizing the book ("this is awful to tell children"), and expressing surprise ("whoa, whoa, whoa, but they are so cute"). Relevant to this last role, parents' questions often seemed to be directed at the book or the experimenter, not the child ("They eat monkeys? Is that true?"), and we saw no indication that parents selectively used questions for pedagogical purposes. Children made more comments about negative facts if their parents asked more questions about those facts ($r = .72$, $p < .001$), but they also made more comments if their parents made more comments ($r = .63$, $p < .001$), suggesting that parents' comments and questions played similar roles in the conversation, prompting more discussion in general.

A limitation of Study 2 is that we did not measure what children learned from the conversation, such as what they remember about the animals and whether they interpret that information as specific to the animal or true of many animals. In Study 3, we address this limitation by eliciting conversations with the same book of animal facts but adding a postconversation interview with the child. Of interest was whether children might recall more negative facts than neutral ones, as well as whether they might interpret the negative facts as less generalizable. If so, parents' selective elaboration of negative facts may convey the message that these facts are anomalies, specific to the animals in the book, rather than widespread patterns of behavior.

Study 3

The goal of Study 3 was to replicate the conversational patterns from Study 2 while also assessing what children learn from these conversations. We assessed children's memory for the facts, as well as their intuitions about the generalizability of those facts, in a follow-up interview with the experimenter. We expected that children would spontaneously recall more negative facts than neutral ones, particularly if those facts were emphasized by their parents, but we also expected that children would judge the negative facts as less generalizable. Parents' additional commentary on negative facts may signal that these facts are unusual or atypical, hence the need for qualification.

Method

Participants

Our participants were 72 parent–child groups recruited from the same public parks as in Study 2. A G*Power analysis indicates that a sample of this size was sufficient for detecting a medium-sized, nondirectional difference between two dependent measures with 98% confidence. Fifty-seven groups consisted of one parent and one child; 13 consisted of one parent and two children, and 2 consisted of one parent and three children. Three additional groups were tested but excluded because their data were unusable (one parent conversed with her child in Spanish; one parent gave the book to the child to read by himself; and one parent read the book from start to finish without involving the child). The children ranged in age from 4 to 11, with a mean age of 6.3 years ($SD = 1.7$). Fifty-five percent of the children were female, and 65% of the parents were female.

Procedure

We used the same book from Study 2 and gave parents the same instructions, that is, to review the book with their child in whatever way they wanted as long as they covered all eight animals. Conversations ranged in length from 10.3 to 33.0 min, averaging 15.4 min ($SD = 4.4$). Following the conversation, children were interviewed separately by the experimenter. The interviews focused on three animals—horned frogs, cuckoos, and meerkats—which were chosen for their taxonomic diversity, as well as the diversity of their negatively valenced behaviors (cannibalism, siblicide, and coalitional violence, respectively). For each animal, children were asked what they remembered about it. The question was open-ended ("What do you remember about horned frogs?") and was followed by one additional prompt ("Anything else?"). To compare the recall rates for negative facts and neutral facts, we divided the number of negative facts recalled by three (one per animal) and the number of neutral facts recalled by nine (three per animal).

Following the recall task, children were reminded of one negative fact and one neutral fact about each animal, regardless of whether they recalled that fact on their own, and they were asked whether they thought that fact was specific to the animal in the book or might be true of other animals as well. The generalization questions were framed in terms of the next highest level of folk categorization. For horned frogs, children were asked whether other frogs engage in the behavior (e.g., "Do you think horned frogs are the only frogs that eat each other or might there be other frogs who do that as well?"); for cuckoos, they were asked whether other birds engage in the behavior; and for meerkats, they were asked whether other mammals engage in the behavior. Children's judgments that a fact could be generalized to other animals were summed separately for negative facts and neutral facts and divided by three, to obtain the mean proportion of each type deemed generalizable.

Results

Conversational Patterns

As in Study 2, parents did not omit the negative facts when discussing the book with their children but rather elaborated on those facts, regardless of the child's age (see Figure 4). We confirmed these findings with repeated-measures ANOVAs, in which fact type (negative vs. neutral) was the repeated measure and age of the youngest child in the group was a covariate. These analyses confirmed that parents repeated negative facts and neutral facts with equal frequency ($F(1, 70) = 0.01$, $p = .913$, $\eta_p^2 = .00$) but were more likely to comment on negative facts ($F(1, 70) = 12.40$, $p < .001$, $\eta_p^2 = .15$) and ask questions about negative facts ($F(1, 70) = 6.39$, $p = .014$, $\eta_p^2 = .08$). Children were more likely to comment on negative facts as well ($F(1, 70) = 4.16$, $p = .045$, $\eta_p^2 = .06$). None of these effects were qualified by interactions with the child's age.

Parents made more comments when conversing with younger children than with older children ($F(1, 70) = 6.41$, $p = .014$, $\eta_p^2 = .08$), but this was the only measure that varied by age. Parents of younger children reviewed the book in much the same way that parents of older children did. Regarding the valence of parents' comments and questions, parents once again used more negatively valenced language for negative facts than neutral facts ($M = 25\%$ vs. $M = 2\%$; paired-samples $t = 9.25$, $p < .001$). Most parents (89%) used valenced language in reference to at least one negative fact, whereas few parents (32%) used this language in reference to any neutral facts ($\chi^2 = 36.71$, $p < .001$). As in Study 2, parents' use of valenced language was uncorrelated with their child's age ($r = -.16$, $p = .18$).

Item Effects

Both Study 2 and Study 3 demonstrate different conversational patterns for negative and neutral facts, but is it emotional valence that's driving these differences? Or might the negative facts be more distinctive and, hence, more surprising? We explored this possibility by recruiting a sample of lay adults (44 college undergraduates) and asking them to rate each of the 32 animal facts on how surprising it is (a measure of distinctiveness) and how disturbing it is (a measure of negative valence). Ratings were made with a sliding scale from 0 to 100. We then averaged participants' ratings for each fact and compared ratings' for negative facts to those for neutral facts. Negative facts were rated as more disturbing than neutral facts ($M = 38.9$ vs. $M = 5.3$, $t(30) = 10.38$, $p < .001$), but they were also rated as more surprising ($M = 38.0$ vs. $M = 18.5$, $t(30) = 3.73$, $p < .001$).

To determine whether participants' conversational patterns were driven primarily by the facts' valence or distinctiveness, we ran a series of hierarchical regressions in which the number of responses elicited by each fact, summed across Studies 2 and 3, were regressed against the facts' disturbingness

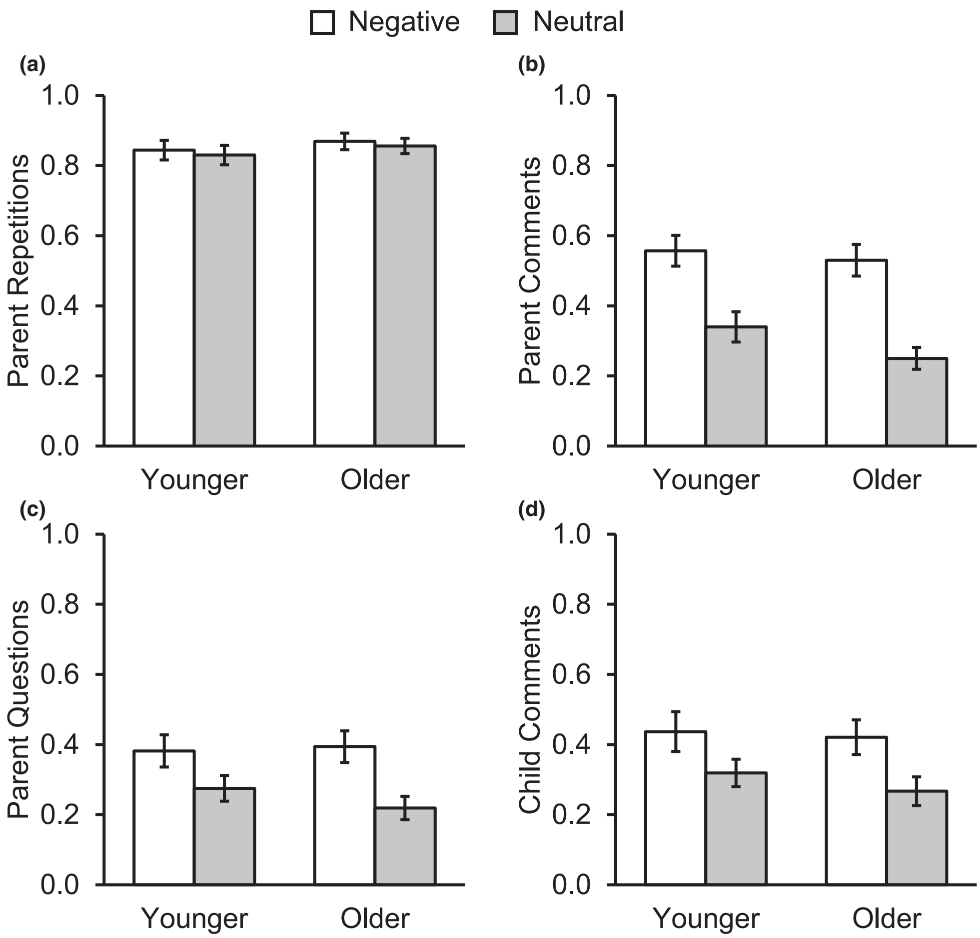

Figure 4. Mean proportion of negative and neutral facts that (a) parents repeated, (b) parents commented on, (c) parents asked questions about, and (d) children commented on, as a function of the child's age (Study 3).

ratings after controlling for their surprisingness ratings. The results of these analyses are displayed in Table 3. For all conversational patterns, a regression model that included disturbingness ratings explained significantly more variance than a model that included only surprisingness ratings (parent questions: $\Delta R^2 = .13$, $F(1, 29) = 4.85$, $p = .036$; parent comments: $\Delta R^2 = .16$, $F(1, 29) = 10.20$, $p = .003$; parents' use of valenced language: $\Delta R^2 = .37$, $F(1, 29) = 60.40$, $p < .001$; child comments: $\Delta R^2 = .19$, $F(1, 29) = 7.94$, $p = .009$). The facts' valence predicted how participants talked about them above and beyond their distinctiveness.

Table 3
Standardized Coefficients for Item-Level Predictors of Participants' Reactions to the Animal Facts in Studies 2 and 3 (Combined)

Measure	Predictor	Model 1	Model 2
Parent questions	Surprisingness	.35	−.07
	Disturbingness		.55*
Parent comments	Surprisingness	.63***	.16
	Disturbingness		.61**
Parent valenced responses	Surprisingness	.68***	−.04
	Disturbingness		.94***
Child comments	Surprisingness	.35	−.17
	Disturbingness		.67**

*$p < .05$. **$p < .01$. ***$p < .001$.

Postconversation Interviews

Children's memory for the facts, following the conversation, is displayed by fact type in Figure 5. Children recalled negative facts more often than neutral facts ($F(1, 85) = 19.39$, $p < .001$, $\eta_p^2 = .19$), and older children recalled more facts in general ($F(1, 85) = 18.20$, $p < .001$, $\eta_p^2 = .18$), but there was no interaction between fact type and age. Children's tendency to generalize the facts is also displayed in Figure 5. On average, they thought about half the facts could be generalized to other animals ($M = 53\%$, $SD = 33\%$), but they generalized neutral

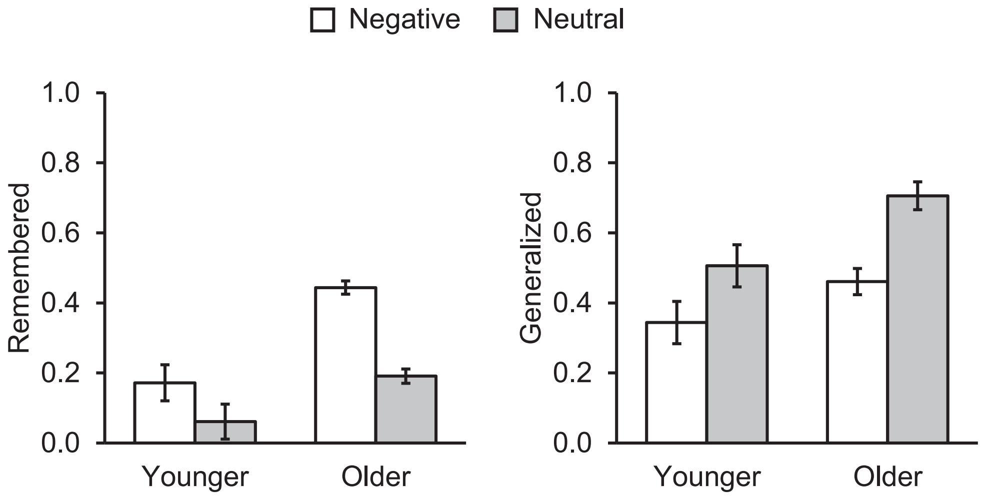

Figure 5. Mean proportion of negative and neutral facts that children remembered and generalized, as a function of the child's age.

facts more often than negative ones ($F(1, 85) = 23.84$, $p < .001$, $\eta_p^2 = .22$). Older children were more likely to generalize facts than younger children ($F(1, 85) = 7.78$, $p = .007$, $\eta_p^2 = .08$), but the difference in fact type held across age, as there was no interaction between the two variables. We also found no correlation between children's ability to recall the negative facts and their tendency to generalize them to other animals ($r = -.05$, $p = .677$).

In one final analysis, we compared children's responses on the postconversation interview to their parents' responses during the conversation. We summed the number of comments that parents made about horned frogs, meerkats, and cuckoos (the three animals covered in the interview) and then compared those sums to children's recall scores and generalization judgments for each type of fact. We did the same for parents' questions. We found that the frequency of parents' comments predicted children's memory for negative facts ($r = .34$, $p < .01$), as did the frequency of parents' questions ($r = .56$, $p < .001$). Neither type of utterance predicted children's memory for neutral facts (all $r < .08$), nor did they predict children's generalization judgments for negative facts or neutral facts (all $r < .13$). Parents' discussion of the negative facts appears to have made those facts easier to recall, but that discussion had little bearing on children's memory for neutral facts or their intuitions about generalizability.

Discussion

The main findings from Study 2 were replicated in Study 3. Parents were just as likely to repeat negative facts as neutral ones, and they elaborated on negative facts with more comments and questions. Children were also more likely to comment on the negative facts. Parents did not vary in how often they repeated the facts, as they did in Study 2, but parents of younger children once again made more comments. In both studies, there were no interactions between fact type and children's age, indicating that when parents highlighted negative facts over neutral ones, they did so regardless of whether their child was a young preschooler or an older elementary schooler. They also used valenced language when conversing with children of different ages, making it clear that the negative facts described behaviors that were bad, mean, or wrong.

Study 3 extends the findings from Study 2 by showing that children interpret negative facts differently than neutral ones. Children are more likely to remember the negative facts but less likely to generalize them beyond the animal in the book. These effects held for both younger children and older children, despite baseline differences in memory and generalization. While it's possible that children remembered negative facts better than neutral facts because the facts themselves are more salient, children's recall of negative facts was predicted by how often their parents elaborated on those facts, implying that parental input may have facilitated children's memory. The lack of correlation between parental input and generalization judgments, on the other hand, suggests that negative facts may strike children as inherently unique, possibly because their knowledge of biology is already biased in favor of neutral or positive interactions.

Item analyses indicate that participants' increased responsiveness to negative facts was driven by how disturbing they found the facts, not how surprising. The books did contain several surprising facts that were neutral in valence, such as the fact that horned frogs sound like cows or the fact that golden eagles can see eight times farther than humans. Facts like these elicited more responses than unsurprising ones, but disturbing facts elicited the most responses. Future research could distinguish the effects of surprise from the effects of valence more directly by describing the same phenomenon in either neutral terms or negative terms. For instance, the negative fact that horned frogs eat other horned frogs could be compared to the neutral (but surprising) fact that horned frogs eat food as large as themselves. This design would not only provide tighter controls on the content of biological texts but would also help distinguish valence from surprise in assessing what children learn from those texts.

Future research could also explore whether parents tend to characterize negative biological information in generic terms ("horned frogs eat other horned frogs") or more individuating terms ("this one eats other frogs") and how such characterizations influence children's interpretations. Generic language is common in parent–child conversation (Gelman, Goetz, Sarnecka, & Flukes, 2008), as well as discourse about scientific ideas (DeJesus, Callanan, Solis, & Gelman, 2019), but parents may refrain from using such language if they think the information at hand has limited generalizability. The current task was not designed to probe differences between generic and nongeneric language, as all facts were expressed in generic terms (e.g., "cuckoos break all other eggs in the nest when they hatch"). But if the facts were expressed in nongeneric terms (e.g., "this bird breaks all other eggs in the next when it hatches"), researchers could explore whether the valence of those facts influences parents' use of generics when relaying them, as well as whether parents' choice of framing influences children's tendency to generalize those facts beyond the animal at hand.

A limitation of Studies 2 and 3 is that parents were not given an opportunity to review the animal-fact book before reading it with their child and thus had limited opportunity to decide whether, and how, they should relay the information contained within. Parents may have omitted more of the negative information if they had time to reflect on it, or they may have used that information as a teaching opportunity, eschewing valenced language for pedagogically focused questions. Another limitation is that we did not measure participants' prior knowledge of the relevant biological concepts. Parents' decisions about what information to discuss is likely shaped by their background knowledge of the prevalence and purpose of biological processes, and children's receptivity to this input is likely shaped by similar factors. The parents in our sample may have possessed greater-than-average knowledge of biology, given they were recruited from an area with higher-than-average socioeconomic indicators, and this knowledge may have increased the degree to which they engaged with the book and, consequently, the negative biological facts.

On the other hand, high socioeconomic status is associated with a more permissive attitude toward norm violations (Caravita, Giardino, Lenzi, Salvaterra, & Antonietti, 2012; Haidt, Koller, & Dias, 1993), so our parents may actually have underreacted to the book's negative information, which was chosen to violate norms of human behavior. Future research should sample parent-child dyads from a wider range of socioeconomic backgrounds and include measures of participants' prior biology education, particularly their knowledge of relevant ecological concepts. This research might also probe what kind of biological information parents think is appropriate for young children to learn and how this information should be taught. Nature books may be viewed as an excellent vehicle for introducing neutral or positive information but a less-than-desirable one for introducing negative information, which might be better introduced in a classroom, zoo, or museum.

General Discussion

How is nature portrayed in children's books and book-based conversations? Our findings suggest it is portrayed more as a "peaceable kingdom" than "red in tooth in claw." Information about disease, parasitism, predation, extinction, differential survival, differential reproduction, interspecies competition, and intraspecies competition is either absent or marked as unusual. These concepts are underrepresented in children's books relative to concepts that lack emotional valence, particularly concepts that pertain to the properties of individual organisms. Most children's nature books focus on organisms' habits and habitats, and far fewer broach relations among organisms, especially relations that may appear disturbing or offensive.

When parents encounter negatively valenced information in children's books, they do not hide that information from their children but rather highlight it, commenting on it and asking questions about it. While parental input might serve to counterbalance the scarcity of negative information in published books, it could also reinforce the idea that unpleasant aspects of the biological world are abnormal or even immoral (Piazza, Landy, & Goodwin, 2014). Consistent with the latter possibility, we found that children processed negative facts differently than neutral ones, remembering them more but generalizing them less.

The representation of negative information in nature books did not vary much by genre or reading level, and its treatment in parent–child conversation did not vary by the child's age. Negative information was least common in fiction books and books for younger readers, but the differences were small: 15% of the concepts in fiction were negative compared to 18% in the other genres (combined) and 14% of the concepts in the lowest quartile of reading level were negative compared to 17% in the other quartiles (combined). Likewise, negative information was marked as unique by parents of younger children and older children alike. Similar patterns of input across books and conversations indicate that the message children receive about negative aspects of the biological world is consistent, regardless of how old they are or what types of books they read.

How might children interpret this input? The absence of negatively valenced activities in children's nature books may suggest that such activities are absent from nature as well. If Jenny Jellyfish is untroubled by predators, parasites, disease, hunger, and the loss of offspring, shouldn't the same be true of other jellyfish? Parents may not shield their children from negatively valenced information, as book publishers do, but they mark that information as atypical, either directly through comments or indirectly through questions. As a consequence, children may quarantine the information and develop overly benevolent views of nature, where organisms are thought to cooperate but not compete.

The patterns of input documented here are consistent with the ecological and evolutionary misconceptions documented in older populations (Shtulman, 2006; Zimmerman & Cuddington, 2007) and may actually contribute to those misconceptions. From a developmental perspective, the earlier children can be taught a scientific framework for understanding natural phenomena, the better, as this framework promotes accurate encoding of domain-relevant information and forestalls the entrenchment of naïve misconceptions (Kelemen et al., 2014; Shtulman, 2017).

That said, it's an open question whether biased input about nature fosters misconceptions or is merely a consequence of those misconceptions. Conceiving of ecosystems as hierarchical networks of interdependent relations is difficult (Hmelo-Silver & Pfeffer, 2004), as is conceiving of evolution as the selective propagation of fitness-enhancing traits within a population (Shtulman, 2006). The simplistic views we develop instead minimize the role of competition, leading to the misconception that competition is unusual or unimportant. In this way, sanitized depictions of nature in children's books may be a byproduct of how lay adults understand nature rather than a deliberate attempt to exclude negatively valenced information. Future research is needed to determine whether biased depictions of nature foster, rather than just accompany, misunderstandings about ecology and evolution, as well as whether providing children with more realistic depictions is educationally efficacious.

It's also an open question whether children are predisposed to interpret negative biological information differently from neutral information regardless of its frequency in children's books or its emphasis in parent–child conversation. In our postconversation interviews, children demonstrated increased memory for negative facts but decreased willingness to generalize those facts. Might these patterns hold in the absence of parental input, marking those facts as unique? Might they hold in contexts where children are fully aware of negatively valenced interactions among organisms, either because they are exposed to more realistic depictions of nature or because they can observe those interactions firsthand? Research with children raised in rural environments or by parents with biological expertise could help address these questions. Children raised in rural environments demonstrate greater understanding of ecology (Coley, 2012) and physiology (Ross, Medin, Coley, & Atran, 2003), as do children raised by parents with biological expertise (Tarlowski, 2006). These children might also demonstrate greater understanding of emotionally charged biological processes, like those studied here.

If more accurate depictions of nature foster more accurate conceptions of ecology and evolution, one could argue that children should learn about all aspects of nature, not just the ones lacking negative valence. But such an approach raises questions about when, and how, to introduce children to negative information. Animals engage in more aggression and violence than portrayed in our animal-fact book, including rape, infanticide, and torture. Adults are often unprepared to learn about such behaviors, let alone children. Consider the public's reaction to live video feeds of osprey nests and eagle nests (Brulliard, 2016). These nests are the site of much biological competition: hatchlings attacking one another, hatchlings stealing food from one another, mothers neglecting one hatchling in favor of another, even mothers eating their hatchlings. Members of the public who have observed such behavior have launched campaigns to save neglected hatchlings, expressing their outrage with comments like "I realize this is nature but ... you have a responsibility to help save when in need" and "it is absolutely disgusting that you will not take those chicks away from that demented witch of a parent!"

These reactions betray naïve views of biology that could benefit from remediation, but they also suggest that some types of biological information may be too aversive to share without proper scaffolding or contextualization. Whether children should be exposed to a more balanced representation of nature is thus an ethical question as well as an educational one. Biological competition is not inherently negative in nature and children could easily be taught about differential survival or resource limitation in ways that circumvent a negative emotional response. Instilling a love of the biological world may be critical for establishing a sustained interest in nature, which has benefits for both physical and mental health (Kaplan & Kaplan, 1989). Still, a full understanding of nature entails concepts that are unavoidably negative—infanticide, siblicide, cannibalism, forced copulation, necrosis—and the question of how to broach such topics requires considering not only the conceptual ramifications of nature's portrayal but also its emotional ramifications.

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Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

Appendix S1. Materials and data for Study 1.
Appendix S2. Materials and data for Study 2.
Appendix S3. Materials and data for Study 3.