Parent-Child Conversation About Negative Aspects of the Biological World

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Abstract

The biological world includes many negatively-valenced activities, like predation, parasitism, and disease. How do parents discuss these activities with their children? Parents of children aged 4 to 12 (n = 147) were asked to discuss an illustrated book of animal facts to their child. Some facts were neutral (e.g., "meerkats live in groups of 2 to 30") and some were negative (e.g., "meerkats wage war on neighboring colonies to expand their territory"). Parents did not selectively omit negative facts. Instead, they selectively embellished those facts, adding their own comments and questions, often couched in explicitly negative language. Children, in turn, were more likely to remember the negative facts but less likely to generalize them 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.

Keywords: conceptual development, science education, folkbiology

Introduction

To understand ecology and evolution, one has to appreciate not just the properties of individual organisms but also relations among organisms, including the struggle for existence within and between species. Is such information available to young learners? 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 and popular media (Rosengren et al., 2014). Here, we explore the representation of negatively-valenced information in parent-child conversation, a source of input central to the construction of early biological knowledge. We explore not only the character of this input but also the impact it may have on children's interpretation of biological processes.

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 relations among 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 this information when describing or discussing biological phenomena with children, and the absence of this input may wrongly imply that negatively-valenced activities are absent from nature.

Research on how adults understand ecology and evolution suggests that competition does not play a central role in that understanding. Most adults view evolution as a non-competitive process, where organisms are born with the traits they need to survive, leading to the uniform transformation of a species without any selection (Bishop & Anderson, 1990; Shtulman, 2006). Many adults also believe that stable ecosystems are characterized by ample food, water, and shelter; a harmonious balance between overpopulation and extinction; and the capacity for all species to survive and reproduce (Zimmerman & Cuddington, 2007).

When adults are asked to estimate the frequency of various inter-organism behaviors, most 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 critical to biological systems just like competitive behaviors, but it's an open question whether people's emotional reactions to a behavior shapes whether and how it is included in biological discourse, particularly if that discourse is directed to young learners still attempting to discern how biological systems work and what biological processes constitute widespread regularities.

In Study 1, we explore how parents treat negatively-valenced information when discussing nature books with their children. We hypothesized that they would selectively omit this information, particularly when conversing with younger children. This hypothesis turned out to be wrong—we find that parents actually 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 such 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 Study 2 by asking children whether the facts they learned in the book generalize to other animals.

Study 1

Method

Participants. Our participants were 75 parent-child groups recruited from public parks in Los Angeles County. 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, 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).

Age was treated as a continuous variable in our analyses, but we split the groups by the age of the child involved for the purposes of data presentation (Tables 2-4). Groups with children under six are labeled “younger” (*n* = 50), and groups with children over six are labeled “older” (*n* = 25). We classified multi-child groups by the age of the youngest child in the group because we expected that if parents censor their speech, they would be more inclined to do so for younger children. 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 in either study.

Materials. Participants were provided with a book containing information about 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 fact about its behavior or relation to humans. For instance, horned frogs were said to (1) occupy the wetlands of South America; (2) eat lizards, mice, and other horned frogs; (3) live by themselves, and (4) make a croak that sounds like the bellow of a cow. Meerkats were said to (1) occupy the plains of Africa; (2) eat insects, spiders, snails, and lizards; (3) live in groups of 2 to 30 individuals; and (4) 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 1. 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. Complete texts for the animal-fact book can be found on the Open Science Framework at https://osf.io/g7e8y/, along with the data for both studies.

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.

Table 1: The negative animal facts.

Animal	Fact
Chimps	Eat fruit, 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

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 was 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 were coded as comments (comprising less than 3% in total). 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 the youngest child. The results remain the same if we exclude multi-child groups.

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 1 and 2 (Cohen’s kappa = .78), and all disagreements were resolved through discussion. Because the books contained more neutral facts than negative facts, we analyze participants' utterances by their relative frequency. That is, we divided the number of parent repetitions, parent questions, parent comments, and child comments by 8 for the negative facts (one for each of eight animals) and by 24 for the neutral facts (three for each of eight animals).

Results

The language patterns from the storybook task are presented in Table 2. We submitted each measure to a repeated-measures ANCOVA, 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 ($F(1,73) = 1.59$, $p = .211$, partial $\eta^2 = .02$), but they were more likely to comment on negative facts ($F(1,73) = 9.05$, $p = .004$, partial $\eta^2 = .11$) and more likely to ask questions about negative facts ($F(1,73) = 12.12$, $p < .001$, partial $\eta^2 = .14$). Children were slightly more likely to comment on negative facts than neutral facts, but this trend was not reliable ($F(1,73) = 2.27$, $p = .136$, partial $\eta^2 = .03$).

In terms of age, parents with younger children repeated fewer facts than parents with older children ($F(1,73) = 17.80$, $p < .001$, partial $\eta^2 = .20$), but they made more comments about the facts ($F(1,73) = 4.23$, $p = .043$, partial $\eta^2 = .06$) and asked more questions about them as well ($F(1,73) = 8.12$, $p = .006$, partial $\eta^2 = .10$). None of these effects were qualified by interactions between children's age and the type of fact under 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 ($r = -.16$, $p = .16$).

Table 2: Mean proportion of negative and neutral facts (+*SE*) that elicited repetitions, comments, and questions, as a function of the child's age (Study 1).

Measure	Fact type	Younger	Older
Parent repetitions	Negative	.66 (.04)	.86 (.04)
	Neutral	.68 (.04)	.84 (.05)
Parent comments	Negative	.42 (.04)	.30 (.06)
	Neutral	.26 (.03)	.16 (.03)
Parent questions	Negative	.31 (.04)	.17 (.05)
	Neutral	.19 (.03)	.10 (.03)
Child comments	Negative	.22 (.03)	.20 (.05)
	Neutral	.14 (.02)	.10 (.03)

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 these facts, adding their own comments and questions, often using explicitly negative language. These trends held regardless of the child's age. 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, parents were generally 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 their own 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's tendency to comment on the negative facts was correlated with their parents' tendency to ask questions about those facts ($r = .72$, $p < .001$) but not substantially more than with parents' tendency to make comments ($r = .63$, $p < .001$), suggesting that comments and questions played similar roles in the conversation.

A limitation of Study 1 is that we did not measure what children learned from the conversation: what they remember about the animals and whether they interpret this information as specific to the animal or more generally true. In Study 2, we address this limitation by eliciting conversations about the same book and adding a post-conversation 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 2

Method

Participants. Our participants were 72 parent-child groups recruited from the same public parks as in Study 1. Fifty-seven groups consisted of one parent and one child; 13 of one parent and two children, and 2 of one parent and three children. The children ranged in age from 4 to 11, with a mean age of 6.3 years (*SD* = 1.7 years); 55% of the children were female, and 65% of the parents were female.

Procedure. We used the same book from Study 1 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. Following the conversation, children were interviewed separately by the experimenter. The interviews focused on three animals: horned frogs, cuckoos, and meerkats. For each animal, children were asked to recall information about that animal. 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, whether other birds engage in the behavior; and for meerkats, 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 (one for each of three animals).

Results

Conversational Patterns. As in Study 1, 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 Table 3). We confirmed these findings with repeated-measures ANCOVAs, 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 ($F(1,70) = 0.01$, $p = .913$, partial $\eta^2 = .00$), but they were more likely to comment on negative facts ($F(1,70) = 12.40$, $p < .001$, partial $\eta^2 = .15$) and ask questions about negative facts ($F(1,70) = 6.39$, $p = .014$, partial $\eta^2 = .08$). Children were more likely to comment on negative facts as well ($F(1,70) = 4.16$, $p = .045$, partial $\eta^2 = .06$). 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 ($F(1,70) = 6.41$, $p = .014$, partial $\eta^2 = .08$), 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 included 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 far fewer (32%) used this language in reference to any neutral facts ($\chi^2 = 36.71$, $p < .001$). As in Study 1, parents’ use of valenced language was uncorrelated with their child’s age ($r = -.16$, $p = .18$).

Table 3: Mean proportion of negative and neutral facts (+*SE*) that elicited repetitions, comments, and questions, as a function of the child’s age (Study 2).

Measure	Fact type	Younger	Older
Parent repetitions	Negative	.84 (.03)	.87 (.02)
	Neutral	.83 (.03)	.86 (.02)
Parent comments	Negative	.56 (.04)	.53 (.05)
	Neutral	.34 (.04)	.25 (.03)
Parent questions	Negative	.38 (.05)	.39 (.05)
	Neutral	.28 (.04)	.22 (.03)
Child comments	Negative	.44 (.06)	.42 (.05)
	Neutral	.32 (.04)	.27 (.04)

Item Effects. Both Study 1 and Study 2 demonstrate different patterns of behavior for negative facts than 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 (a) how surprising they are and (b) how disturbing they are using a sliding scale from 0 to 100.

To determine whether participants’ conversational patterns were driven by the facts’ negative valence above and beyond their surprisingness, we ran a series of hierarchical regressions in which the number of comments or questions elicited by each fact, summed across studies, were regressed against the facts’ negative-valence ratings after controlling for their surprise ratings. For all measures, a regression model that included negative-valence ratings explained significantly more variance than a model that included only surprise ratings (parent questions: $\Delta R^2 = .13$, $F(1,29) = 4.85$, $p = .036$; parent comments: $\Delta R^2 = .16$, $F(1,29) = 10.20$, $p = .003$; parent valenced responses: $\Delta R^2 = .37$, $F(1,29) = 60.40$, $p < .001$; child comments: $\Delta R^2 = .19$, $F(1,29) = 7.94$, $p = .009$). Thus, raters’ perceptions of how disturbing the facts were predicted participants’ reactions to those facts independent of their distinctiveness.

Post-Conversation Interviews. Children’s memory for the facts, following the conversation, is displayed by fact type in Table 4. Children recalled negative facts more often than neutral facts, as revealed by a repeated-measures ANCOVA ($F(1,85) = 19.39$, $p < .001$, partial $\eta^2 = .19$). Older children recalled more facts than younger children ($F(1,85) = 18.20$, $p < .001$, partial $\eta^2 = .18$), but there was no interaction between fact type and age. Children’s tendency to generalize the facts is also displayed in Table 4. On average, they thought about half the facts could be generalized to other animals (M = 53%, SD = 33%), but they judged neutral facts as more generalizable than negative ones ($F(1,85) = 23.84$, $p < .001$, partial $\eta^2 = .22$). Older children were more likely to generalize facts than younger children

($F(1,85) = 7.78$, $p = .007$, partial $\eta^2 = .08$), 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 ($r = -.05$, $p = .677$).

Table 4: Mean proportion of negative and neutral facts (+*SE*) that children remembered and generalized, as a function of the child's age (Study 2).

Measure	Fact type	Younger	Older
Remembered	Negative	.17 (.05)	.44 (.05)
	Neutral	.06 (.02)	.19 (.02)
Generalized	Negative	.34 (.06)	.46 (.04)
	Neutral	.51 (.06)	.71 (.04)

In one final analysis, we compared children's responses on the post-conversation interview to their parents' utterances 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 parent 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 1 were replicated in Study 2. Parents were as likely to repeat negative facts as neutral facts, and they elaborated on negative facts with more comments and questions. Children were also more likely to comment on the negative facts. Parents of younger children did not cover fewer facts than parents of older children, as they did in Study 1, but parents of younger children once again made more comments when reviewing the facts. In both studies, there were no interactions between fact type and children's age, indicating that when parents highlighted negative facts over neutral facts, 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 2 extends the findings from Study 1 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 facilitated children's memory. The lack of correlation with generalization judgments, on the other hand, suggests that negative facts may strike children as inherently unique, possibly because their perceptions of nature are 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, after all, include several surprising facts that did not carry negative valence, such as that horned frogs sound like cows or that golden eagles can see eight times farther than humans. Still, future research could distinguish the effects of surprise from the effects of negative 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 can eat food as large as themselves. This design would also help distinguish the roles of negative valence and surprise in what children learn from conversations about novel phenomena.

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 et al., 2008), as well as discourse about scientific ideas (DeJesus et al., 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 non-generic 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 non-generic 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 to their children. Generics foster a sense of prevalence in both children (Brandone et al., 2015) and adults (Cimpian et al., 2010), particularly when they convey information about distinctiveness or danger, so this language could counter children's reluctance to generalize negative facts when first encountered.

Other language patterns that could be analyzed in more detail include parents' use of anthropomorphic language, their use of moral language (beyond valence), and their discussion of the broader biological context in which the behavior occurs. Anthropomorphic language and moral language might further imply that negative behaviors are atypical, but contextual information could hint at their functional affordances and, hence, ecological value.

General Discussion

How do parents talk to their children about negatively-valenced biological information? Contrary to expectation, they do not hide that information but rather highlight it, commenting on it and asking questions about it. This input may 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. Negative information was marked as unique by parents of younger children and older children alike, suggesting that this input remains constant across development.

If parents mark negatively-valenced information as atypical, either directly through comments or indirectly through questions, children may quarantine that information and develop overly benevolent views of nature, where organisms are thought to cooperate but not compete. Such input is consistent with the ecological and evolutionary misconceptions documented in older populations (Shtulman, 2006; Zimmerman & Cuddington, 2007) and may 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 a consequence of those misconceptions. Conceiving of ecosystems as a hierarchical network of interdependent relations is difficult (Hmelo-Silver & Pfeffer, 2004), as is conceiving of evolution as the byproduct of selective reproduction within a population (Shtulman, 2006). The simplistic views we develop instead minimize the role of competition, and competition, in turn, may become viewed as unusual or unimportant. 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 would interpret negative biological information differently from neutral information regardless of its emphasis in parent-child conversation. In our post-conversation 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 et al., 2003), as do children raised by parents with biological expertise (Tarlowski, 2006). These children might also demonstrate greater understanding of the importance and prevalence of emotionally-charged biological processes.

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, children should be introduced to such information. Animals engage in more aggression and violence than portrayed in our 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). Those 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. Children are prone to learn more from positive sources of information than negative ones (Boseovski, 2010; Boseovski & Thurman, 2014), suggesting that early exposure to the darker side of nature could demotivate them. Whether and how children should be exposed to negative biological information is thus an ethical question as well as an educational one.

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