


Using Animals to Teach Children Biology: Exploring the Use of Biological Explanations in Children’s Anthropomorphic Storybooks

Megan Geerds , Gretchen Van De Walle, and Vanessa LoBue

Department of Psychology, Rutgers University

ABSTRACT

Research Findings: Anthropomorphism—the attribution of human characteristics to nonhuman entities—has long been a staple of children’s media. However, children’s experiences with anthropomorphic media may interfere with biological reasoning instead encouraging an anthropocentric view of the natural world. To date, little research has addressed the typical content of children’s storybooks about animals: Do these storybooks present factual information that may support early developing biological reasoning, or do they instead focus on human-centered, psychological information that may encourage anthropocentrism? We analyzed the types of causal explanatory information that commercial storybooks about animals provide to children about 2 biological concepts that have been extensively studied in the experimental literature: biological inheritance and the transmission of illness. Using coding schemes similar to those used in prior experimental literature to assess preschool-age children’s biological reasoning, we found that none of the anthropomorphized books presented children with scientifically accurate causal mechanisms. These books focused almost exclusively on social-emotional experiences as opposed to biological explanations, which may inadvertently encourage anthropocentric reasoning. *Practice or Policy:* Understanding more about the content of informal sources of early learning can help inform educators on how to best support developing knowledge about the natural world and biological properties.

Over the past 30 years, a number of researchers have investigated the origins and developmental trajectory of children’s folkbiological knowledge of the natural world. One prominent view argues that children take a decidedly anthropocentric view of the natural world, conceptualizing humans and animals as distinct and extending biological properties to animals only in the context of their psychological similarity to humans (e.g., Carey, 1985). Also in line with this view, preschool-age children often fail to produce biologically specific causal explanations for biological events, such as contagion (e.g., Bibace & Walsh, 1981; Kister & Patterson, 1980) and biological inheritance (e.g., Solomon, Johnson, Zaitchik, & Carey, 1996), further suggesting that their understanding of the natural world is embedded within a folkpsychological explanatory framework. Although researchers have debated the innateness of folkbiology, different presentations of the natural world can affect children’s use of either biological or psychological reasoning (e.g., Waxman, Herrmann, Woodring, & Medin, 2014). However, little work has explored the content of children’s early informal experiences related to anthropocentric and biological reasoning.

In the current research we explore the kinds of evidence that children receive about the natural world and biological events that may shape the emergence of folkpsychological and folkbiological reasoning. First we discuss recent research highlighting the role that anthropomorphic media may play in encouraging anthropocentric reasoning and interfering with biological, factual learning. We

present findings from a content analysis of children's animal picture books about biological properties in order to explore whether these kinds of books typically may support biological or anthropocentric reasoning. Better understanding the kind of evidence that children receive from informal learning sources, before formal schooling introduces biological explanations, can inform understanding of the developmental trajectory of young children's conceptual reasoning.

The Development of Biological Reasoning

Over the past 30 years, the nature of children's understanding of the biological world has been hotly debated (e.g., Carey, 1985; Inagaki & Hatano, 2002; Keil, 1994; Wellman & Gelman, 1998). A central focus of the argument has revolved around whether young children organize their understanding of living things within a biological or psychological framework. To assess early biological reasoning, researchers often use a biological induction task pioneered by Carey (1985). In the task, the researcher introduces an unobservable biological property (e.g., "People have spleens inside") and then asks the participant whether he or she thinks this property also applies to other animals, plants, or objects. Carey found that whereas adults reason biologically, children reason anthropocentrically: Young children readily extend properties taught on humans to other animals but make few generalizations from animals to humans or to other animals. Young children use humans as a prototypical species and extend biological properties based on behavioral similarity to humans. Over the course of early childhood, formal and informal learning experiences teach children about biological functioning and support the organization of knowledge about living things around a causally coherent and specifically biological framework (Carey, 1985; Solomon & Johnson, 2000).

In addition to research on children's general reasoning about the biological world, a large body of literature has investigated children's reasoning about specific relevant biological properties, such as contagion and biological inheritance. If children have a distinctly autonomous domain of biology, they should also demonstrate biological causal reasoning about biological properties. Research on children's developing understanding of these phenomena has yielded mixed results with respect to whether children can provide appropriate and biologically specific causal explanations for each. For instance, experimental research on children's understanding of biological inheritance often uses a cross-species adoption paradigm, in which children are presented with a baby born to one family but raised by another and are asked whether the baby will grow up to resemble the birth parents or adoptive parents on physical, behavioral, and psychological traits. For example, will a baby horse raised by cows grow up to (a) look like a horse or a cow and (b) neigh or moo? Some studies have found that it is not until at least 7 years old that children correctly favor the biological parent for physical resemblance but the adoptive parent for behavioral resemblance (e.g., Solomon et al., 1996). Young children are even willing to accept that psychological causal factors, such as maternal intentions, can influence the inheritance of both physical and psychological traits (Weissman & Kalish, 1999). Furthermore, even some children who can correctly answer prediction questions cannot correctly justify their answers and may therefore have failed to embed this knowledge in a coherent, biological causal theory (Johnson & Solomon, 1997; Williams, 2012). Similarly, children often fail to use biologically specific causal explanations of contagion-related events and are willing to attribute illness to a variety of psychological causes, such as bad behavior or wishing to be sick (Bibace & Walsh, 1981; Kister & Patterson, 1980; Perrin & Gerrity, 1981; Solomon & Cassimatis, 1999).

Children's Media and Biological Reasoning

This large body of research on children's biological reasoning has recently been extended by a growing interest in the informal learning experiences that may shape early conceptual reasoning. Cultural input is clearly important for shaping the reliance of folkbiological or folkpsychological reasoning. For instance, in communities in which alternative frameworks for illness (i.e., different from Western biomedical frameworks) are available, both children and adults endorse culturally

specific alternative beliefs, such as supernatural causal mechanisms (e.g., Inagaki & Hatano, 2002; Legare, Evans, Rosengren, & Harris, 2012; Legare & Gelman, 2008). What kinds of informal sources may encourage young children to develop anthropocentric or biological reasoning about the natural world before exposure to formal schooling?

One source that has been the focus of a growing body of research is children's picture books. Nearly all (91%) children in the United States younger than the age of 5 years have been exposed to storybooks, with the average age of first exposure at 5 months (Common Sense Media, 2011). Furthermore, 83% of children younger than the age of 6 years read or are read to each day for an average of 48 min, regardless of family income (Rideout & Hammel, 2006). Thus, storybook reading is a prevalent experience in young children's daily lives that may serve as an important source of cultural learning before formal schooling.

Recent research has shown that preschool-age children can learn about the natural world and biological processes from storybooks and that the presentation of information can affect children's reasoning about animals (e.g., Ganea, Ma, & DeLoache, 2011; Geerdts, Van de Walle, & LoBue, 2015b; Kelemen, Emmons, Seston Schillaci, & Ganea, 2014; Legare, Lane, & Evans, 2013). Ganea et al. (2011) found that even children as young as 4 years old were able to generalize information about color camouflage from storybook animals to real animals. Storybook interventions can also be used to teach young children more complex biological properties: 5- to 8-year-old children read scientifically accurate natural selection narratives exhibited significant gains in knowledge about evolution, especially in the youngest age group (Kelemen et al., 2014). Thus, storybooks can serve to increase children's biological knowledge.

Of particular relevance to how children learn about the biological world, children's storybooks are full of anthropomorphic animals. An examination of more than 1,000 modern picture books found that nearly half featured animals as significant characters, with only a quarter of those animals featured in natural settings. However, even when portrayed in their natural settings, these animals were typically anthropomorphized with names, communicative abilities, and recognizably human behavior (Marriott, 2002). However, storybooks that portray animals anthropomorphically may interfere with biological learning and further encourage anthropocentric reasoning. Preschool-age children read anthropomorphic storybooks are less likely to use biological reasoning (Waxman et al., 2014) and less likely to learn factual information (Ganea, Canfield, Simons-Ghafari, & Chou, 2014). Waxman et al. (2014) read 5-year-old children either a realistic animal storybook (*First Animal Encyclopedia*) or an anthropomorphic animal storybook (the Berenstain Bears) before completing the biological induction task (Carey, 1985). Children read the realistic storybook exhibited a biological pattern of responses, attributing new biological properties between animals and humans equally. However, children of the same age who were read an anthropomorphic storybook exhibited the typical anthropomorphic, human-centered pattern of reasoning. Thus, anthropomorphic storybooks may support human-centered reasoning, whereas realistic storybooks may encourage biological reasoning. Similarly, Ganea et al. (2014) found that anthropomorphic storybooks, especially those with anthropomorphic pictures, do affect children's willingness to attribute psychological properties to animals. For example, 3-, 4-, and 5-year-old children who were read an anthropomorphic storybook about an unfamiliar animal were more likely to generalize psychological properties to real animals and, for younger children especially, were less likely to remember novel facts about the animals than children read a factual storybook. Similarly, 5- to 12-year-old children read stories with anthropomorphic explanations about evolutionary change ("Brownbirds like to have different beaks because they want to eat different sorts of food") were more likely to endorse desire-based, anthropomorphic evolutionary explanations than those read stories with need-based or natural selection explanations (Legare et al., 2013).

Although this growing body of research suggests that factual representations may be more beneficial for supporting biological reasoning, a confounding factor is the kind of information presented within these storybooks. Waxman et al. (2014) compared children's reasoning after reading one of two books about bears that differed in terms of the realism of the animals, but the

books also differed in the kind of information highlighted. The anthropomorphic book focused on human-specific events related to social-emotional issues, like the trouble with getting children to stick to bedtime routines, whereas the factual book presented information such as the habitat and diet of bears. In other studies that have more closely controlled the kind of information, children did not show substantial differences in biological reasoning and in fact learned just as much about biological properties from anthropomorphic books (Ganea et al., 2011; Geerdts et al., 2015b). For instance, in a recent study (Geerdts et al., 2015b), 4- and 5-year-old children were read a book about color camouflage that presented factual, biological explanations but used either realistic or anthropomorphic language and pictures. Here anthropomorphism did not decrease factual learning: Children were not more likely to explain camouflage using psychological, intentional explanations. An important question then is what kinds of explanatory information about biological properties do commercial anthropomorphic storybooks provide?

The Current Research

In the current study, we ask whether storybooks with animal characters provide causal explanatory information about these biological properties. To the extent that they do provide causal explanations, are these explanations biological or psychological in nature? Thus, the major goal of this study is to examine whether children's biological storybooks with animals provide a potential source of information to support the development of sophisticated biological knowledge. Storybooks about cross-species adoption, for example, may attribute physical resemblance to biological parents and behavioral resemblance to adopted parents. In addition, they may explain why the inheritance of physical and behavioral properties differs by contrasting the role of inheritance or origins with that of shared experiences. However, they may also fail to provide such information. The use of anthropomorphism in particular may lead readers to focus on psychological mechanisms typical of humans, such as family bonds and emotional ties. In the current study, we are interested in examining whether storybooks provide children with the specific type of information they would need to succeed on experimental tasks used to assess children's biological causal knowledge. Thus, we create our coding schemes by adapting schemes used in prior research to code children's explanations for these biological phenomena. We may find that the types of explanations commonly present in these storybooks resemble the explanations used by children in previous research.

Informal learning experiences, such as picture book reading, may be especially relevant sources of biological information for preschoolers. As children begin formal schooling, they are taught factual and causal biological knowledge. For instance, by first grade, formal instruction about germs is part of the Common Core State Standards in many states (California Department of Education, 2011). Potential informal, cultural sources of biological reasoning, like picture books, are most relevant prior to formal schooling. Thus, in the present study, we focus on storybooks marketed to a preschool audience.

Methods

Storybook Selection

One of the largest online book retailers, Amazon.com, was used to compile a list of storybooks in June 2012. Broad keywords (*adoption*, *illness*, and *contagion*) were used to produce an initial sample. We then applied limiters to restrict our search to English-language children's storybooks for preschoolers (ages 3–6 years). Storybooks were scanned for content to be sure that they fit our age and language limiters, were designed for a general audience (i.e., we excluded religious storybooks, storybooks created specifically for adopted children, and storybooks that aimed to help children overcome their fear of the doctor), and featured animal main characters. The result was a sample of 20 adoption books and 25 illness books (see the [Appendix](#) for a full list of titles and authors).

Coding

All of the storybooks were analyzed and coded for (a) the use of anthropomorphism and (b) explanations/mechanisms regarding each biological property.

Anthropomorphism

Both the language and pictures in each book were coded for the use of anthropomorphism. *Anthropomorphism* is defined here as the attribution of human-specific characteristics (e.g., motivations, behaviors, actions) to nonhuman animals. Each book was placed into one of four categories based on how animals were depicted throughout the story:

- (1) Realistic pictures and realistic language
- (2) Realistic pictures and anthropomorphic language
- (3) Anthropomorphic pictures and realistic language
- (4) Anthropomorphic pictures and anthropomorphic language

Books were coded as having anthropomorphic pictures if the animals were depicted engaging in any human-specific behaviors or possessing human-specific capabilities (e.g., living in a house, reading, walking upright, wearing clothing). Books that depicted animals engaging in species-typical behaviors and actions were coded as realistic. Books were coded as using anthropomorphic language if intentional language was used to describe the animals' behavior (Ganea et al., 2011) or if the animals were ever depicted as speaking or thinking, either explicitly through direct speech or implicitly through narration. Books were coded as using realistic language if they used only neutral, factual language to describe or explain the animals' behavior without implying underlying mental states or human-specific capabilities. Two coders (the first author and an undergraduate research assistant) independently coded all of the storybooks. Interrater reliability between the two raters indicated very good agreement (Cohen's $\kappa = .809$). A third trained coder reviewed both coders' selections, and any disagreements were resolved through discussion between the third and first coders.

Explanations for Biological Properties

The text of each storybook was also coded for reference to biological and psychological explanations and/or mechanisms regarding each biological property. The explanations and mechanisms were selected on the basis of prior research that investigated children's own explanations for the biological properties.

Biological Inheritance. The text of each biological inheritance storybook was coded for reference to specific physical and behavioral similarities and differences between offspring and their biological and adoptive parents. These coding definitions were derived from prior experimental research investigating children's domain-specific causal understandings of inheritance (Johnson & Solomon, 1997; Solomon et al., 1996; Williams, 2012; Williams & Smith, 2006). Our coding scheme focused on possible sources for the offspring's physical (i.e., bodily characteristics) and nonphysical (i.e., beliefs, emotions, preferences, activities) traits. Comments about specific traits were classified according to the context within which they were described using the following categories:

- Inheritance: the passing of traits from parents to offspring via biological inheritance or biological kinship (e.g., "Jimmy got his blue eyes from his parents' genes" or "Susan inherited her mom's love of traveling")
- Adoptive family resemblance: a general statement that either compared or contrasted adoptive family members regarding resemblance on specific properties without providing a possible mechanism for resemblance (e.g., "From the beginning, Jack was much bigger than his sisters")

- Biological family resemblance: a general statement that either compared or contrasted biological family members regarding resemblance on specific properties without providing a possible mechanism for resemblance (e.g., “Pink’s brother and sister piglets were strong and healthy, but he was tiny and weak”)
- Generic references to category membership: generic statements that appealed to the individual’s membership in a specific category to explain the possession of a specific trait (e.g., “Cats drink milk”)

In addition, for nonphysical properties, the following two codes were applied:

- Shared social activities (adoptive): a social activity shared with the adoptive family members (e.g., “The three of them walked home and talked about all of the things they would do as a family”)
- Shared social activities (biological): a social activity shared with the biological family members (e.g., “They liked to wrestle and nip at each other”)

Contagion. For the illness stories, the coding scheme focused on possible mechanisms for illness causation. The scholarly literature on children’s understanding of illness and contagion generally focuses on whether children conceptualize illness as caused by a biological mechanism (germs) or a psychological mechanism (punishment for bad behavior, desires). We coded the illness stories based on the presence of the following possible explanations (regardless of scientific accuracy) for why the character(s) became sick:

- Germs: These stories explicitly mentioned germs, viruses, bacteria, or any other medical origin for the illness.
- Physical proximity: This code was used if the story either explicitly or implicitly mentioned physical proximity as a possible cause; for instance, a story in which a character took care of one character who was sick and then himself or herself became sick with no reference to any other mechanism was coded as providing a physical proximity mechanism.
- Behavioral: This code was used for any specific activity or behavior that led to the child getting sick, such as not wearing a coat or eating too much junk food.
- Psychological: This code was used for any psychological or magical cause that led to getting sick, such as wishing to be sick, witchcraft, or punishment for behaving badly.
- Unspecific/irrelevant: These stories simply described the illness event with no specific mention of any cause.

Each storybook was coded binomially as either having made reference or not having made reference at any point in the storybook to each possible category of information. Thus, one storybook may have received more than one code. Two coders (the first author and an undergraduate research assistant) independently coded all of the titles. Interrater reliability between the two raters for the adoption stories was found to be moderate (Cohen’s $\kappa = .55$), and for the illness stories interrater reliability was found to be substantial (Cohen’s $\kappa = .74$). A third trained coder reviewed both coders’ selections, and any disagreements were resolved through discussion.

Results

Anthropomorphism

First we explored the use of anthropomorphic language and images in the adoption and contagion storybooks. Results are summarized in Table 1. None of the cross-species adoption storybooks used realistic or factual language; all used anthropomorphic language to describe the animals as

possessing complex feelings, emotions, and behaviors and engaging in social interactions. However, it was not necessarily the case that anthropomorphic language was always accompanied by anthropomorphic images: Close to a third of the storybooks (30%) portrayed the animals visually using realistic drawings or photographs. Many of the storybooks showed animals in their natural habitat behaving realistically despite using narration to tell a very human, emotional story. However, this may have been due more to the nature of the story than a desire to represent animals accurately. To make the theme of an individual being adopted into a different family as obvious as possible, it may be easiest to maintain the visual and behavioral differences between the species rather than portraying them all visually as humans.

Similarly, none of the illness storybooks used realistic, factual language; rather, all used anthropomorphic language. In addition, nearly all of the illness books (96%) used anthropomorphic drawings. Illness books were significantly more likely to use anthropomorphic drawings than the adoption books, $\chi^2(1, N = 45) = 5.72, p = .017$. The only illness book that did not use anthropomorphic drawings was one that told the true story of a sick sea turtle that was found, rescued, cured, and released using real photographs. However, this story still used heavily anthropomorphic language to describe how the sea turtle, named Caroline, was feeling and what she was thinking as she recovered from the “turtle flu” (Rathmell, 2005, p. 4).

Explanations for Biological Properties

Biological Inheritance

The adoption storybooks were coded for reference to specific physical and behavioral similarities and differences between offspring and their biological and adoptive parents. Results are presented in Table 2. Overall, storybooks were more likely to focus on behavioral than physical properties: All books made at least one reference to behavioral properties, whereas only 60% of the books referred to physical properties, $\chi^2(1, N = 40) = 7.66, p = .006$.

For physical properties, none of the storybooks used inheritance, the correct biological mechanism, to explain the transmission of physical properties between parents and their biological offspring. About a third of the books provided biological family resemblance (30%) and/or category membership (30%) as possible sources for the child’s physical properties. Given that biological families should be more physically similar than adoptive families, we were interested in seeing whether explicit comparisons were more often made between biological and adoptive families. Chi-square tests revealed that the books were no more likely to draw physical property comparisons between the child and his or her biological family than between the child and his or her adoptive family, $\chi^2(1, N = 40) = 0.94, p = .33$. Thus, storybooks did not provide any

Table 1. Number (%) of Storybooks With Anthropomorphic Language and/or Pictures.

Type of Book	Realistic Pictures, Realistic Language	Realistic Pictures, Anthropomorphic Language	Anthropomorphic Pictures, Realistic Language	Anthropomorphic Pictures, Anthropomorphic Language
Adoption books	0	6 (30%)	0	14 (70%)
Illness books	0	1 (4%)	0	24 (96%)

Table 2. Number (%) of Biological Inheritance Books That Were Coded as Having Made Reference at Any Point in the Storybook to Each Possible Category of Information.

Property	Inheritance	Adopted Family Resemblance	Biological Family Resemblance	Generic Category Reference	Shared Social Activities (Adopted)	Shared Social Activities (Biological)
Physical	0 (0%)	10 (50%)	6 (30%)	6 (30%)	-	-
Nonphysical	0 (0%)	7 (35%)	0 (0%)	9 (45%)	14 (70%)	2 (10%)

information about biological mechanisms for physical inheritance but instead focused simply on comparing and contrasting physical properties between different family members and/or animal kinds.

For behavioral properties, similarly, none of the storybooks referenced inheritance in explaining the possession of specific behavioral properties. As with physical properties, some books provided adoptive family resemblance (35%) and/or generic category references (45%) as possible sources for the child's behavioral properties. Most frequently, the books referred to social activities that were shared with the adoptive family (70%). Little behavioral information was given about the biological family at all: No books referred to biological family resemblance for behavioral properties, and only two books (10%) made reference to shared social activities with the biological family. As adopted children should share more similarities with adopted parents in terms of behavioral properties, we compared references to biological and adoptive families for behavioral and social properties. It was significantly more likely for books to contain references to the adoptive family than the biological family in both behavioral resemblance and shared social activities: behavioral resemblance, $\chi^2(1, N = 40) = 6.23, p = .013$; shared social activities, $\chi^2(1, N = 40) = 12.60, p = .004$.

Contagion

Here we present results for biological and psychological explanatory information found in the illness storybooks. Results are presented in Table 3. Like the adoption storybooks, most illness storybooks (88%) failed to provide the correct, biologically specific causal mechanism underlying the phenomenon of contagion. No storybooks specifically mentioned germs, but two did mention medical causes, including tonsils and needing an operation to "fix a stripe that slipped out of place" (Janosch, 1985, p. 14). Many stories implied that physical proximity contributed to the transmission of illness (36%), but none of these referenced actual mechanisms of transmission such as germs. In many stories, a character got sick and then the character's caregiver soon became sick, leading to a role reversal in the care relationship. These stories did not mention why illness is contagious or how it passes between individuals but provided evidence that physical proximity may be a possible factor. Few stories mentioned psychological (8%) or behavioral (12%) causes of illness. Often stories did not mention any possible mechanisms for illness (36%) and simply focused on the experience of being sick.

Discussion

A large body of previous research has focused on the content and development of young children's early understanding of the biological world (e.g., Carey, 1985; Inagaki & Hatano, 2002; Wellman & Gelman, 1998). However, little previous research furnishes data from which one can draw conclusions about the information that is present in children's everyday experiences and how this input may contribute to children's knowledge development. In the current research, we focused on one specific and common cultural influence that may affect the development of biological and anthropocentric reasoning: children's storybooks.

We found that media depicting animals engaging in a biological event often present a psychologically motivated story. The adoption and illness storybooks almost always portrayed animals anthropomorphically in both pictures and language. These results are consistent with prior literature reporting that animals in children's media are largely portrayed as human-like, with a focus on social and emotional traits (e.g., Marriott, 2002).

In addition, these storybooks do not appear to be a potential source through which children could learn factual, biologically specific causal mechanisms, in that they rarely referred to biological inheritance or

Table 3. Number (%) of Illness Books That Were Coded as Having Made Reference at Any Point in the Storybook to Each Possible Category of Information.

Germs	Physical Proximity	Behavioral	Psychological	Unspecific/Irrelevant
3 (12%)	9 (36%)	3 (12%)	2 (8%)	9 (36%)

germs. Stories about cross-species adoption never referenced biological inheritance in explaining physical differences between an adopted child and an adoptive family of a different species. The storybooks did often highlight shared social experiences with the adoptive family, which may help children understand that these environmental factors are important for the transmission of behavioral properties. However, they did not do the same for physical properties: Although the storybooks often compared and contrasted the child and the adoptive parents, they rarely referenced biological parentage as a possible source of physical properties. The common overall theme of these books was that family is defined not by physical or genetic commonalities but by emotional and social connections, with no mention made of the role of biological parentage in the adoptee's possession of specific physical properties.

Similarly, illness stories focused on the physical and emotional consequences of being sick and often presented physical proximity as an important factor in predicting contagion. Given our findings of the kind of input children may receive in typical informal learning experiences, it is not very surprising that children themselves do not always reason according to specifically biological causal mechanisms in empirical adoption and contagion paradigm tasks. It is interesting that illness storybooks rarely use the kinds of psychological causal explanations that some previous research has found children often provide themselves, such as citing illness as punishment for doing something wrong or immoral (Bibace & Walsh, 1981; Kister & Patterson, 1980). Thus, the animals in both sets of storybooks we analyzed largely taught about important emotional and relational properties rather than explaining the biological facts important for understanding these properties.

These findings have important methodological and theoretical implications. Empirical studies frequently use the cross-species adoption paradigm to assess children's naïve biology (e.g., Johnson & Solomon, 1997; Solomon et al., 1996; Springer, 1996; Springer & Keil, 1991). This paradigm pits social against biological influences on property transfer from parent to child. However, the current work examining the information presented to children via published books suggests that from this common childhood media activity children are not receiving input that reflects a clear differentiation of biological and social sources for physical and behavioral properties. Storybooks are much more apt to focus on social influences and properties, neglecting the role of biological parents in physical property transmission. Furthermore, children were never provided with explicit causal information such as biological inheritance. Thus, it is perhaps not surprising that many children have failed to provide biologically relevant responses in the empirical literature (e.g., Bibace & Walsh, 1981; Johnson & Solomon, 1997; Kister & Patterson, 1980; Solomon et al., 1996), as it is not clear that they are receiving the relevant information from at least one of their everyday experiences.

Theoretically speaking, this work has implications for the origins of children's anthropocentric reasoning bias. Our research is consistent with the proposal that the development of anthropocentrism is mediated by experiences (e.g., Herrmann, Waxman, & Medin, 2010; Waxman & Medin, 2007). Specifically, Waxman and colleagues (2007, 2014) have postulated that children raised in urban environments are exposed to anthropomorphized animals through media and cultural discourse and that these experiences lead children to adopt an anthropocentric view of the natural world. Although the current work was not experimental and therefore provides no causal evidence concerning the direction of the relationship between media and knowledge, it does demonstrate that at least one form of media to which children are widely and frequently exposed from a very young age—storybooks—almost exclusively promotes such an anthropocentric bias. The storybooks we analyzed highlighted psychological and behavioral characteristics of animals, simultaneously omitting information on biological properties of animals or on biologically relevant aspects of adoption or contagion. Although both urban and rural children may be similarly exposed to such media, urban children may be less likely to have other, more biologically accurate experiences of animals to counter such anthropomorphized media portrayals. Prior experimental research suggests that anthropomorphism interferes with the development of biological reasoning and factual learning (Ganea et al., 2014; Legare et al., 2013; Waxman et al., 2014), suggesting that much of children's informal literature on the biological properties focused on in the present study may not be supporting biological learning at all and may in fact be contributing to the development of anthropocentric reasoning.

This study was limited in scope because we only focused on one source of potential information for preschoolers—picture books. Specifically, we chose to narrowly focus on storybooks with animals to see whether biological explanations may be used in conjunction with anthropomorphic depictions of the natural world. It is entirely possible that books with human characters contain different kinds of explanations and may be more apt to focus on biological explanations than the books we reviewed here. In addition, children certainly gather information about biological properties from other sources, including other forms of media, parents, siblings, and firsthand experiences like being sick. However, other research suggests that the findings reported here are highly representative of other typical experiences preschool-age children have that have to do with animals and biological concepts. For instance, children's interactions with parents in book reading (Geerdts, Kim, & Van De Walle, 2013) and in zoos and science centers (Geerdts, Van de Walle, & LoBue, 2015c), interactions with teachers in preschool settings (Kallery & Psillos, 2004; Thulin & Pramling, 2009), and even direct interactions with companion pets (Geerdts, Van de Walle, & LoBue, 2015a) are highly likely to contain anthropomorphic information. In addition, during storybook reading about cross-species adoption, parents provide information that is very similar to the storybooks we analyzed in the current study, with no focus on biological inheritance and a substantial focus on shared social experiences that tie families together (Geerdts et al., 2013). Together with the current research, these observations of parents and their children provide further support for the conclusion that children (especially from urban, majority populations) are exposed to anthropocentric biases through both media and discourse.

To date, a large amount of research has focused on children's developing understanding of biological concepts for a largely theoretical purpose: to better understand the origins and development of children's naïve domains of knowledge. Conceptual tasks have been focused on understanding when children understand biological and psychology as separate domains of reasoning about the natural world. However, little research has focused on the everyday experiences and larger cultural influences, such as media, that impact the developmental trajectory of children's biological concepts. Future work should continue to combine experimental with more descriptive and naturalistic methodologies, characterizing real-world experiences so that researchers can later measure learning outcomes experimentally. Such methodologies can help experts gain a better understanding of how direct and indirect daily experiences can optimally support early biological knowledge development. For educators specifically, research on early sources of informal learning can shed light on the emerging understanding of biology that children bring to the classroom. Better understanding the kinds of information that children are receiving outside the classroom can highlight the areas that educators can focus on to optimally support early biological knowledge development. Our research shows that many of children's everyday interactions with biological concepts are not providing causal explanatory information, which may be an area that early education teachers can target with interventions. Additional research is also needed to provide recommendations for educators about the kinds of books, anthropomorphic or factual, that support factual biological knowledge development while still engaging children in learning about the natural world.

Acknowledgments

Megan Geerdts is now in the Department of Undergraduate Psychology at Chestnut Hill College.

ORCID

Megan Geerdts  <http://0000-0003-4398-0128>

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Appendix

List of Titles and Authors of Analyzed Children's Books`

Adoption Storybooks

A Mother for Choco by Keiko Kasza
Little Miss Spider by David Kirk
Guji Guji by Chih-Yuan Chen
A Mama for Owen by Marion Dane Bauer and John Butler
Our Twitchy by Kes Gray and Mary McQuillan
Little Pink Pup by Johanna Kerby
Nikolai, the Only Bear by Barbara Joose and Renata Liwska
Mrs. Hen's Big Surprise by Christel Desmoinaux
Cora and the Elephants (Picture Puffins) by Lissa Rovetch
You're Somebody Special, Walliwigs by Joan Rankin
The Little Green Goose by Adele Sansone and Faust Anke
Owen and Mzee by Michelle Y. Glennon
Bullfrog and Gertrude Go Camping by Rosamond Dauer
Goose by Molly Bang
Honey Badgers by Jamison Odone
Paddington Bear by Michael Bond and R. W. Alley
The Nanny Goat's Kid by Jeanne Willis and Tony Ross
Giant Jack by Birte Muller
All Together Now by Anita Jeram
Stellaluna by Janell Cannon

Illness Storybooks

Ah-choo! Lion's Got the Flu by Hagino Chinatsu
Bear Feels Sick by Karma Wilson and Jane Chapman
The Berenstain Bears: Sick Days by Jan Berenstain and Mike Berenstain
Carolina's Story: Sea Turtles Get Sick Too! by Donna Rathmell and Barbara J. Bergwerf
Doctor Maisy by Lucy Cousins
Don't You Feel Well, Sam? by Amy Hest and Anita Jeram
Dr. Duck by H. M. Ehrlich and Laura Rader
Feel Better, Ernest! by Gabriel Vincent
Felix Feels Better by Rosemary Wells
How Do Dinosaurs Get Well Soon? by Jane Yolen and Mark Teague
I Wish I Was Sick, Too! by Franz Brandenburg and Alike
I'll Make You Well, Tiger, Said the Bear by Janosch
Little Brown Bear Is Sick by Claude Lebrun and Daniele Bour
Little Raccoon Catches a Cold by Susan Canizares and Christopher Denise
Llama Llama Home With Mama by Anna Dewdney
Marty Moose Gets Sick by Kiki
Miss Bindergarten Stays Home from Kindergarten by Joseph Slate and Ashley Wolff
Morris Has a Cold by Bernard Wiseman
Pigs Make Me Sneezel! by Mo Willems
Sam and Violet's Get Well Book by Nicole Rubel
Taking Care of Mama by Mitra Modarressi
Teddy Bears Cure a Cold by Susanna Gretz and Alison Sage
The Sick-in-Bed Birthday by Linda Wagner Tyler
The Sniffles for Bear by Bonny Becker and Kady MacDonald Denton
Who's Sick Today? by Lynne Cherry
