ANTHROPOMORPHIC MEDIA AND CHILDREN’S BIOLOGICAL KNOWLEDGE

by

MEGAN GEERDTS

A Dissertation submitted to the

Graduate School-Newark

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Psychology

written under the direction of

Dr. Gretchen Van de Walle

and approved by

_____________________________________________

_____________________________________________

_____________________________________________

_____________________________________________

Newark, New Jersey

May 2014
ABSTRACT OF THE DISSERTATION

Anthropomorphic Media and Children’s Biological Knowledge

By MEGAN GEERDTS

Dissertation Director:
Gretchen Van de Walle

Anthropomorphism, the attribution of human characteristics to non-human entities, has long been a staple of children’s media. However, little research has directly measured the effect of anthropomorphism on children’s developing conceptual knowledge about animals. How does seeing a dancing, talking bear that lives in a house impact children’s understanding of biological and psychological properties of real bears? In Studies 1 and 2, the use of anthropomorphism in popular children’s television and storybooks was analyzed. In Study 3, parents reported on their children’s actual exposure to and preference for anthropomorphic media, verifying the findings in Studies 1 and 2. In Study 4, a parent-child storybook reading paradigm explored parent’s own use of biological and social language to explain biological properties to their children. Finally, in Study 5 we experimentally examined the impact of anthropomorphic language and/or pictures in storybooks on children’s anthropocentrism and learning about biological properties. Contrary to previous research, storybooks with anthropomorphic pictures led to an increase in children’s willingness to project a novel biological property from both humans and animals to other animals, thus decreasing anthropocentrism. Boys who were read a storybook with anthropomorphic pictures showed the highest performance on a
generalization task. Additionally, both boys and girls provided higher-level explanations about the biological property after being read an anthropomorphic storybook. Thus, anthropomorphic media may actually help children learn by increasing similarities between humans and animals. Suggestions for future research are discussed. The current research sheds important light on the educational implications of anthropomorphism in children’s media, parent-child interaction, early childhood science education, and the development of children’s biological concepts.
Preface

This dissertation is submitted for the degree of Doctor of Philosophy at Rutgers University, Newark. The research described herein was conducted under the supervision of Dr. Gretchen Van de Walle in the Department of Psychology, Rutgers University, Newark, between May 2012 and May 2014.

The work is an original intellectual product of the author, M. Geerdts, except where acknowledgements and references are made to previous work. Neither this, nor any substantially similar dissertation has been or is being submitted for any other degree, diploma, or other qualification at any other university.

Part of this work has been presented in the following conference formats:


Acknowledgement

I am incredibly grateful for the support of my advisor, Dr. Gretchen Van de Walle, who has generously provided me with support, advice, and resources over the past five years that have been instrumental in helping me become the researcher and scholar I am today. I am especially appreciative to Dr. Vanessa LoBue for an immeasurable amount of writing, editing, and research support over the past two years.

I thank the other members of my committee, Dr. Paul Boxer and Dr. Jennifer Kotler Clarke, for their insightful and supportive comments, suggestions, and edits.

This research has been funded in part through the Rutgers-Newark Psychology Department Dissertation Research Fund.

I would also like to thank past and present members of the Child Research Labs who provided both friendship and research support, in particular to Katy-Ann Blacker, Kaleigh Matthews, Teresa Harvey, Jennifer Irving, and Vivian Kim. Thanks also to my friends and the people I met during my time at Rutgers University, Newark, especially the members of the Graduate Student Government Association.

Finally, to my family for their love, encouragement, and support. Thank you for everything you have done in the past and everything you continue to do that has allowed me to complete this dissertation and pursue my dreams.
# Table of Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
</tr>
<tr>
<td>1.1</td>
<td>Why do we Anthropomorphize?</td>
</tr>
<tr>
<td>1.2</td>
<td>The use of Anthropomorphism in Popular Media</td>
</tr>
<tr>
<td>1.3</td>
<td>Transfer of Behavioral Knowledge from Media to Reality</td>
</tr>
<tr>
<td>1.4</td>
<td>Anthropomorphism and Biological Knowledge Development</td>
</tr>
<tr>
<td>1.5</td>
<td>Current Research</td>
</tr>
<tr>
<td>2</td>
<td>Study 1</td>
</tr>
<tr>
<td>2.1</td>
<td>Methods</td>
</tr>
<tr>
<td>2.1.1</td>
<td>Coding</td>
</tr>
<tr>
<td>2.2</td>
<td>Results</td>
</tr>
<tr>
<td>2.3</td>
<td>Discussion</td>
</tr>
<tr>
<td>3</td>
<td>Study 2</td>
</tr>
<tr>
<td>3.1</td>
<td>Methods</td>
</tr>
<tr>
<td>3.1.1</td>
<td>Coding</td>
</tr>
<tr>
<td>3.2</td>
<td>Results</td>
</tr>
<tr>
<td>3.2.1</td>
<td>Anthropomorphism</td>
</tr>
<tr>
<td>3.2.2</td>
<td>Biological Mechanisms</td>
</tr>
<tr>
<td>3.3</td>
<td>Discussion</td>
</tr>
<tr>
<td>4</td>
<td>Study 3</td>
</tr>
<tr>
<td>4.1</td>
<td>Methods</td>
</tr>
</tbody>
</table>
List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of storybooks (and percent) with anthropomorphic language and/or pictures in Study 2</td>
</tr>
<tr>
<td>2</td>
<td>Mean number of utterances per parent and percent of parents who provided at least one coded statement</td>
</tr>
</tbody>
</table>
# List of Illustrations

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99</td>
</tr>
<tr>
<td>The distribution of television shows falling into each of the three coding categories: educational, format, and subject.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>The percentage and number of younger and older children’s favorite screen media and books that feature anthropomorphic animals.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>101</td>
</tr>
<tr>
<td>Examples of drawings and scripts from the factual and anthropomorphic camouflage storybooks in Study 5.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>102</td>
</tr>
<tr>
<td>Sample trial of our modified biological induction task based on Tarlowski (2006) featuring base (top left), biological property (bottom left), and 3x3 array of targets.</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>103</td>
</tr>
<tr>
<td>Percentage of children in each of the three storybook picture conditions (control, realistic, anthropomorphic) who attributed the novel biological property from humans to animals and from dogs to animals.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>104</td>
</tr>
<tr>
<td>Percentage of children who used anthropomorphic language when recalling the story within each of the four storybook conditions.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>105</td>
</tr>
<tr>
<td>Mean number of correct generalization predictions by boys and girls in each of the three storybook picture conditions (control, realistic, anthropomorphic). Error bars represent SEM.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>106</td>
</tr>
<tr>
<td>Mean explanation score of children in each of the three storybook picture conditions (control, realistic, anthropomorphic). Error bars represent SEM.</td>
<td></td>
</tr>
</tbody>
</table>
Anthropomorphic Media and Children’s Biological Knowledge

Anthropomorphism, the attribution of human characteristics to other animals or non-living things, is incredibly prevalent in everyday language. We often find ourselves cursing our computers, which clearly must have some personal vendetta against us, or attempting to persuade recalcitrant cars to cooperate. We frequently talk about what our pets “know,” “like,” or “think about”; describe animals as being “shy,” “trying to tell you” something, or as having a “point of view”; and believe that they experience “grief” and “friendship” (Horowitz & Bekoff, 2007, p. 25). Many people even explicitly believe that animals can experience humanlike levels of emotional and cognitive states; one study found that 72% of respondents felt that chimpanzees felt pain like humans and 42% thought they had human-like ability to experience emotions (Herzog & Galvin, 1997). Moreover, linguistic metaphors between humans and animals are found in every culture (Caporeal & Heyes, 1997).

Why do we Anthropomorphize?

Psychological research has provided insights into some of the cognitive and neural mechanisms underlying the tendency to view nonhuman agents as human. Researchers argue that our perceptual and attentional systems may be uniquely tuned towards animals. Wilson (1984) suggested that an essential aspect of human nature, arising from our evolutionary past, is an innate attraction to and connection with both nature and animals. More recent research supports and extends his hypothesis. For instance, in a visual scene, adults detect changes involving animate entities more quickly and reliably than changes involving various types of non-animate entities (New, Cosmides & Tooby, 2007). As a result, infants display a greater attentional and emotional
attraction towards animals than other types of stimuli. Not only do infants show visual preferences for animals, but they also direct emotional and communicative behaviors such as smiling, laughing, and waving towards animals significantly more than towards inanimate objects (DeLoache, Bloom Pickard, & LoBue, 2010).

Recent neuroscience research has also identified possible neural mechanisms that may underlie a perceived similarity between humans and animals. Though highly controversial, one such possibility is the mirror neuron system (MNS), neurons that fire both when performing an action and observing that action being produced by another actor (Keysers, 2009). Despite major debates on the function and explanatory power of the MNS, this system is often implicated in the ability to imitate and understand the actions and intentions of other people (Rizzolatti & Craighero, 2004). Thus, defects in this system may underlie deficits in the social domain such as in individuals with autism (Dapretto et al., 2005; Oberman et al., 2005). The system could even support anthropomorphic reasoning. Gazzola, Rizzolatti, Wicker and Keysers (2007) found that activity in the MNS was parallel in response to both human and robotic goal-directed actions (2007). Since the MNS encodes the actions of human and non-human agents similarly, the authors speculate that this common encoding may also lead to perceiving these agents similarly in terms of other attributes such as feelings and intentions. Although there is currently not enough data to support their conclusions, the MNS could be an avenue for future research on the neural basis of anthropomorphism.

Anthropomorphism may be related to another fundamental aspect of human nature: our need to seek social connections. Research has shown that social isolation has many negative consequences, including increased depression and decreased health
ANTHROPOMORPHIC MEDIA AND BIOLOGICAL KNOWLEDGE

(Baumiester & Leary, 1995; Heinrich & Gullone, 2006). As result, researchers have found that lonely people are motivated to seek social connections (Maner, DeWall, Baumeister, & Schaller, 2007; Lakin, Chartrand, & Arkin 2008; Williams, Cheung & Choi, 2000). Anthropomorphizing animals may be a way of creating social agents and thereby serve as a social resource. Epley, Akalis, Waytz, & Cacioppo (2008) found a correlation between loneliness and attribution of anthropomorphic mental states (having a mind of its own, intentions, free will, consciousness, and emotions) to inanimate objects. Furthermore, after inducing loneliness, participants were significantly more likely to attribute anthropomorphic social traits (thoughtful, considerate, sympathetic) to animals.

Anthropomorphism may also stem from an overextension of cognitive frameworks used to explain human behavior to non-human entities. Guthrie (1993) argues that since human social relationships are what matter most to us and are encountered frequently in our daily lives, we instinctively (but wrongly) apply human intentionality to a variety of phenomenon. This automatic tendency to see human intentions in non-human entities can be an adaptive and useful cognitive strategy that helps us to describe, understand, and predict unfamiliar animals. While we may be mistaken to apply this attribute to animals and other natural phenomena, Guthrie considers these mistakes as relatively “cheap” compared to their reward. Some organizations even capitalize on this benefit by intentionally overextending human frameworks to non-human entities. For instance, the World Meteorological Organization system of naming storms (e.g., Hurricane Irene) is used to facilitate communication with the general public and leads to better storm preparedness (Waytz, Epley, & Cacioppo, 2010). In fact, The Weather Channel recently announced that it is extending storm
naming to winter storms this year, stating that naming a storm raises awareness, makes it easier to follow the storm’s progress, simplifies communication, and makes it more memorable. Their storm names for this season include Roman and Greek Gods, Shakespeare characters, NYC subway lines, and ancient leaders (The Weather Channel, 2012, Oct 2).

Similarly, when lacking the appropriate knowledge to explain animal behavior, anthropomorphic language as metaphor can help in scientific theory formation (Asquith, 1997). Metaphor is frequently used in science by explaining or testing one theory in terms of another, for instance likening the orbit of planets around the sun to electrons around a nucleus (Wall, 2009). Some researchers argue that metaphor is necessary for understanding the world, and that all of our scientific theories contain metaphorical concepts (Lakoff & Johnson, 1980). Scientists frequently engage in anthropomorphic language in an attempt to build scientific understanding. Ochs, Gonzales, and Jacoby (1996) observed physicists in a university laboratory and found that they frequently used metaphor language to refer to inanimate, physical entities sentient beings capable of understanding and feeling. Darwin also frequently used anthropomorphic metaphor in his writings; a critical analysis found such metaphors in explaining evolution as a process of change and relationships between species (Pramling, 2008). Thus, whether unconscious and automatic or deliberate, anthropomorphic language and metaphors are frequently engaged to help us understand and explain unfamiliar phenomenon.

Despite its universal prevalence and natural basis, anthropomorphism is often deemed as unscientific. To scientists and ethologists, anthropomorphism is generally seen as categorically false; it is a misattribution of mental states and human behaviors to
animals. The rise in scientific thinking is often linked to a decrease in anthropomorphic attributions and remaining anthropomorphic descriptions are seen as “primitive” (Daston & Mitman, 2005). Unlike laypeople, ethologists attempt to describe animal behavior in a way that is devoid of mental state language. They often criticize anthropomorphic interpretations as anecdotal and subjective rather than systematic and objective (Swartz & Evans, 1997). For instance, in describing animal behavior and reflexes, Pavlov stressed that scientists must focus on the “physiological facts, without any need to resort to fantastic speculations as to the existence of any possible subjective state in the animal which may be conjectured on analogy with ourselves” (Pavlov, 1927).

Indeed, consistent with the ethologists’ and behaviorists’ arguments, the use of anthropomorphism to predict animal behavior can lead not only to bad scientific reasoning, but also to false predictions with dire consequences. For instance, a conceptualization of wild animals as human-like can lead to an expectation of friendly behaviors. One particularly compelling instance of such consequences is presented in the film documentary *Grizzly Man* (Herzog, 2005). It follows Timothy Treadwell, an environmentalist who believed that his life mission was to protect the grizzly bears. He spent his summers camping among the grizzlies in Alaska, sometimes even touching and playing with the bears. He named each bear there and believed that he shared with the bears a mutual sense of trust and respect. However, throughout the documentary he consistently misinterprets animal behaviors through an anthropomorphic lens. For instance, in one scene, the seemingly playful behavior of a bear repeatedly diving in a stream was actually the bear searching for and failing to find food, a sign that food supplies were low which could lead to aggressive behavior. Instead of leaving after this,
Treadwell moved his camp even closer to the bear habitat and extended his stay longer to better watch over and protect them. In the end, Treadwell was killed after being attacked by a grizzly bear. While an extreme case, it certainly shows the dangers of misinterpreting animal behavior through a human lens.

The Use of Anthropomorphism in Popular Media

Despite the potential negative outcomes, laypeople use anthropomorphism on a daily basis. This is especially evident in our art and media. Anthropomorphic animals, objects, mythical creatures, and even forces of nature are well documented in art and literature. Anthropomorphic representations in art have been dated as far back as the Paleolithic era, about 40,000 years ago, to primitive statues and cave drawings depicting human-like animals. Fables, one of the oldest and most widespread forms of storytelling and literature, are characterized by their use of anthropomorphism. Aesop’s fables, dating back to 600 BC and since then translated into countless languages and versions, used anthropomorphic animals to teach uniquely human life lessons. Similarly, the Panachantra, an Indian collection of anthropomorphic fables dated to around 200 BC but based on oral stories from much farther back, is regarded as among the most known literary works in the world. It has been translated into over 200 different versions in more than 50 languages, with versions in most European languages existing by 1600 (Edgerton, 1924).

Literature targeted primarily for children has always been heavily anthropomorphic as well. By the 1600s, a shift in the concept of childhood as an important stage in life for learning led to the advent of children’s literature. As the production of books became easier and cheaper, children’s literature continued to grow as
a popular field. Traditional anthropomorphic folktales were preserved and popularized through children’s literature, such as *Mother Goose* and the Grimm Brothers collections. By the 1930s, children’s literature had become a substantial industry with its own medals, reviewers, and library reading rooms. Today, children’s print and electronic books make up around 25% of the overall book market with over $3 billion in sales in 2010 (Rubin, 2011). Although the format may have changed from print to electronic, modern children’s literature is still heavily anthropomorphic. An examination of over 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).

Children’s media further expanded with the advent of film and television. Walt Disney, who played a pivotal role in shaping American media, created enduring anthropomorphic cartoon characters such as Mickey Mouse, Dumbo, and Bambi (Williams, 1986). Animated films became even more popular and accessible to children with the introduction of television. Saturday morning cartoons brought movie characters such as Bugs Bunny and Tom and Jerry into children’s homes every weekend. Today, it seems that the majority of young children’s movies, television shows, and books feature anthropomorphized animals. An analysis of British children’s TV shows found that a surprising 87% of the programs contained animals, with over half of those programs featuring anthropomorphic animals. An average of 6 animals were shown per program, totaling close to 20 animals per hour of viewing time (Paul, 1996). Even commercials viewed during these television shows are likely to contain anthropomorphized animals.
An analysis of 14 hours of network television broadcasting found that of the 72 commercials with animals, 19% were explicitly anthropomorphized and 26% were pets; only 11% of the animals were shown in nature (Lerner & Kalof, 1999). These rates may be even higher if focusing just on advertising during children’s programming.

Children also show preferences for anthropomorphic media. All of the top 15 highest grossing G-rated movies of all-time feature talking animals or inanimate objects (Bukszpan, 2011). An analysis of storybooks in a preschool lending library found that 59% of the library’s books featured anthropomorphic animals and that a significantly higher proportion of the most frequently checked out books featured anthropomorphic animals than the less popular books (McCrindle & Odendall, 1994). When read similar stories with either human or animal characters, most (74%) of the children expressed a preference for the animal stories (Boyd & Mandler, 1955). Even infants preferentially attend to cartoon, anthropomorphic animals over real animals (DeLoache et al., 2010).

Transfer of Behavioral Knowledge from Media to Reality

Despite its prevalence and popularity, little is known about the consequences of anthropomorphic media on children’s conceptions of real animals. Researchers disagree as to whether anthropomorphism supports or hinders knowledge about real animals. Anthropomorphism may help children better understand animals; just as adults and scientists use anthropomorphic analogy to understand non-human entities as discussed previously, children can analogically apply knowledge about their own behavior and biological functioning to less familiar animals (& Hatano, 1987, 2002;). However this same process could lead children to incorrectly extend human-specific psychological properties to real animals. Insisting that an animal is “just like a person” minimizes the
animal’s own species membership and may lead to an incorrect interpretation of their behavior (Melson, 2001). Just as this incorrect interpretation can lead to disastrous outcomes for adults as discussed earlier (e.g. Herzog, 2005), children’s belief that animals will act like people may be one of the reasons why 50% of dog attacks involve children under the age of 12 and 70% of fatal dog attacks occur among children under 10 (Humane Society of the United States, 2005). However, very little previous work as focused on whether and what kind of information children transfer from media portrayals of anthropomorphic animals to real animals.

There is some research that suggests that anthropomorphic animals are actually helpful to children’s learning about humans. Some types of anthropomorphic representations may be seen as more human than animal; these ‘symbolic humans’ are animals depicted as bipedal, clothed, and able to speak out loud. These animals essentially serve as human stand-ins, especially when teaching children socially and morally beneficial topics (Mierek, 2010). For powerful, personal, or difficult topics, the use of ‘symbolic humans’ rather than actual humans acts as a buffer and adds emotional distance. Children’s literature has often been used as a device to convey social norms and cultural values and animals can soften the teaching message and ease tensions in controversial issues (Burke & Copenhaver, 2004). Additionally, because the direct relationship between child and animal is ambiguous, they can represent human feelings and experiences in a distanced and non-threatening manner (Marriott, 2002). This distance between child and animal also makes basic wishes, fears, needs, and wants universal, avoiding representation of gender or race that may influence identification (Krueger & Krueger, 2005). Walt Disney saw his own cartoon characters in this way,
commenting that Mickey Mouse “was never really a mouse nor yet wholly a man, although always recognizably human, I hope” (Merlock Jackson, 1993). Children's interest in fantasy contexts may even facilitate their learning from these fictionalized ‘symbolic humans’ by increasing attention and motivation (Parker & Lepper, 1992). In contrast to some of the research showing decreased learning transfer from fantasy creatures, Friedman (2011) found that children displayed more sharing behaviors after being read a book about sharing featuring anthropomorphized animals rather than the identical story with human characters. Thus, anthropomorphic animals as ‘symbolic humans’ may not be seen as animals at all and may actually help children learn about humans.

Previous work on children’s media learning suggests that children may not transfer knowledge from anthropomorphic animals to real animals because of the stark difference between the characters and reality; children are better able to generalize new information when there is a higher degree of similarity between the media and the real world object (e.g., Ganea, Pickard, & DeLoache, 2008; Simcock & DeLoache, 2006). Thus, when there is little perceived similarity between the media character and the real world they may not transfer any knowledge. For instance, research suggests that the use of “fantasy” creatures may interfere with children’s ability to transfer knowledge to real life scenarios. Using an analogical problem-solving paradigm, Richert, Shawber, Hoffman, & Taylor (2009) found that preschool-aged children were significantly more likely to transfer solutions from familiar real characters (e.g., their teachers) than from familiar fantasy characters (e.g., Mike & Sully from Monsters Inc.). Thus, fantasy creatures may remain in their own “fictional worlds” separate from the “real world”
(Skolnick & Bloom, 2006). However, there is a crucial distinction between fantasy creatures and anthropomorphic animals in that animals do exist in real-life. Thus, we may find transfer with anthropomorphic animals that more closely resemble their real-world counterparts.

Mierek (2010) refers to anthropomorphic representations of animals that are more similar to their real world counterpart as ‘animal selves.’ These animals may appear in their natural habitat, engage in species typical behaviors, and are generally recognizable as natural to their species. They often narrate stories directly to the reader, but they do not speak out-loud (i.e., using human language) within the story. These realistic characters are meant to provide an insight to the natural animal world in a way that engages children. However, they also imbue animals with a range of psychological and social properties that may be uniquely human. Animal narrators are portrayed as capable of telling an intricate story full of wishes, desires, motivations, intentions, and beliefs.

Misrepresentations through ‘animal selves’ can negatively impact children’s (and adult’s) knowledge of and relationships with real animals. Children readily separate the animal world into “good” creatures, such as dogs, cats, horses, dolphins, and pandas, and “bad” creatures, such as rats, bugs, crocodiles, and wolves, aided by popular portrayals of animal heroes and villains (Paterson, 1989). The image of the “Walt Disney dog”, a loyal, intelligent, heroic dog that will go to any length to save their owner, has led many dog owners to perceive ‘normal’ or appropriate dog behavior as bad, causing many of these dogs to end up abandoned in shelters (Anderson & Henderson, 2005). The “Bambi” portrayal of deer and similar depictions of forest animals as cute, sweet, and lovable has caused major problems for park rangers, with an increasing number of visitors being
attacked after attempting to approach or hand-feed wild animals (Strauss, 2006). Thus, anthropomorphic media characterizations, especially those portrayed as ‘animal selves,’ may produce false knowledge about the behavior of real animals.

**Anthropomorphism and Biological Knowledge Development**

In addition to behavioral knowledge about animals, anthropomorphic media characterizations may impact children’s biological knowledge about real animals. Over the past 30 years, the nature of children’s understanding of living things has been hotly debated. A central focus of the argument has revolved around the origins and development of children’s early understanding of fundamental biological phenomenon concepts such as ‘animal’, ‘plant’ and ‘living thing’. Early research suggested that young children reason about the living world *anthropocentrically*, that is, their view of the biological world is human-centered and psychologically based whereas adults reason biologically, recognizing that humans are one animal among many (Carey, 1985, 1995).

To assess early biological reasoning, researchers often the biological induction task, pioneered by Carey (1985). In the task, the researcher introduces an unobservable biological property (i.e. “people have spleens inside”) and then asks the participant whether they think 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.
A major criticism of early work on children’s biological knowledge development is its failure to take into account variability in experience with animals and the natural world, focusing only on urban majority children in the US (e.g., Waxman & Medin, 2007). Children may have early experiences with animals or be exposed to different cultural views of nature that could impact their early biological concepts. Follow-up cross-cultural research comparing finds consistent cultural differences (e.g., Atran et al., 2001; Ross, Medin, Coley, & Atran, 2003). For instance, Tarlowski (2006) found that 4-year-old rural children and children whose parents were biological experts (e.g., doctors, scientists, zookeepers) were more likely than urban children to exhibit adult-like patterns in their inductive inferences about novel biological properties. Similarly, Waxman & Medin (2007) found that 4 and 5-year-old urban children reasoned anthropocentrically about novel biological properties, replicating the previous findings. However, 4 and 5-year-old rural children reasoned biologically like adults, extending novel properties at similar rates from humans and animals.

These results could be interpreted as showing that anthropocentrism is the first framework children use in early biological reasoning; rural children simply have more first-hand opportunities to gather evidence about animals so they develop more sophisticated biological knowledge at an earlier age. However, a follow-up study using a slightly modified task enabling testing with even younger children found no evidence of human-centered reasoning in urban 3-year-olds. Their previous results were replicated with urban 5-year-olds who showed a strong anthropocentric pattern (Herrmann, Waxman, & Medin, 2010). These results suggests that anthropocentrism, instead of providing an early-developing foundation for the development of biological knowledge,
is learned by older urban children due to their lack of experience with real animals and increased exposure to fictional, anthropomorphic animals.

The conclusion that researchers draw from this body of research is that early experiences with animals impact the course of development of biological knowledge. Specifically, they posit that early experiences with real animals may facilitate biological knowledge development, while increased exposure to fictional animals may increase children’s use of human-centered reasoning strategies. However, these conclusions are merely speculations; none of these studies quantified children’s actual exposure to live animals, anthropomorphic media, or social interactions with their parents. Thus, little is known about the relationship between specific experiences and biological knowledge development. For instance, even within a sample of urban children there are substantial intra-group variations in daily animal exposure. The experience of raising a pet increased children’s ability to use other animals, rather than humans, as an inductive source of biological information (Geerdts, Van de Walle, & LoBue, under review a). To fully understand the relationship between experience and biological knowledge development, research is needed that quantifies children’s experiences with real and fictional animals and further experimentally manipulates exposure to different types of portrayals of animals.

Thus far, a limited number of studies have experimentally investigated the relationship between exposure to anthropomorphic media and biological reasoning about real animals. In one study, school-aged children were read stories about evolutionary change using either factual or anthropomorphistic language accompanied by photographs or drawings of real animals in their natural environments (i.e., the birds wanted to change
their beaks to adapt to their surroundings because they like the hard seeds). Children who heard anthropomorphic stories were more likely to use anthropomorphic language in their own retelling of the story and were more likely to endorse anthropomorphic explanations in a forced choice task (Legare, Lane, & Evans, 2013).

Another recent study looked at whether an anthropomorphic framework would help or hinder preschool-aged children’s generalization of biological facts to real world situations (Ganea, Ma & DeLoache, 2011). Researchers exposed children to storybooks about why animals that were camouflaged were less likely to be eaten than those that were not camouflaged that either used factual language (“the bird doesn’t see the frog because it’s the same color as the things around it”) or intentional language (“The bird doesn’t see Sammy because Sammy’s color is the same as the things around him. Sammy tricked the bird!”). Photographs of animals in their natural habitats accompanied these stories. They found that both 3 and 4-year-olds performed equally well at transferring biological knowledge from the factual and intentional books to novel animal characters and to real animals. Furthermore, very few children in either condition provided camouflage explanations using intentional terms. They concluded that anthropomorphism was just as effective as factual language for teaching younger children about biological processes. However, a follow-up study (Ganea, Canfield, Ghafari, & Chou, 2014) found that anthropomorphic storybooks, especially those with anthropomorphic pictures, do affect children’s willingness to attribute psychological properties to animals. Children who were read a storybook about an unfamiliar animal that provided information about its possession of anthropomorphic qualities were more likely to generalize those same psychological properties to real animals of the same species. Thus, while
anthropomorphism may not affect factual learning, it may lead to differences in children’s reasoning about animals’ possession of psychological properties.

Finally, Waxman, Herrmann, Woodring, & Medin (2014) investigated the effect of anthropomorphic media on children’s anthropocentric reasoning. Researchers exposed 5-year-old children to one of two commercial storybooks depicting bears, a factual children’s animal encyclopedia or an anthropomorphic Berenstain Bears book about bedtime, and then measured children’s attributions of novel biological properties from animals and humans using the biological induction task. Children read the anthropomorphic storybook showed anthropocentric reasoning patterns while children read the realistic storybook showed biological reasoning patterns, suggesting that not only can young children reason flexibly about animals but that the content of children’s media can prime one pattern or the other.

Current research

Overall, a small body of previous research has directly investigated the impact of anthropomorphic media on children’s concepts about real animals. However, there are a number of remaining questions. None of the studies characterized children’s actual media experiences. It is unclear how common different types of anthropomorphic representations are in children’s media across different platforms and learning goals. For instance, educational media or media focused on specific biological processes may be less likely to use unrealistic animals. Additionally, there may be differences between the availability of media and what children actually prefer. We may also find differences in children’s preferences across development for real and fantasy animals. Thus, in the
current research our first goal was to characterize the anthropomorphism most frequently encountered in children’s media as well as their own media preferences and habits.

Second, it is difficult to draw conclusions across the limited body of research due to differences in methodologies, stimuli, ages, and outcome measures. Two of the studies previously discussed (Ganea et al. 2011; Legare et al. 2013) defined anthropomorphism as imbuing animals with human psychological properties, such as desires and intentions, with no visual representation of anthropomorphism and used different age groups (preschoolers and school-aged children). Additionally, these studies only measured the impact of anthropomorphism on children’s factual learning and ability to explain the property. The other two studies did use anthropomorphic pictures (Ganea et al. 2014; Waxman et al. 2014) but the animals were extremely humanized, shown living in houses, and wearing clothing, and performing human actions such as eating at a dinner table or taking a bath in a tub. As discussed above, it is possible that these animals are leading children to think about humans, and beneficial for increasing learning about humans rather than animals (Friedman, 2011; Parker & Lepper, 1992). Whether anthropomorphic representations of animals that are more similar to real animals (Mierek, 2010) also leads to increased anthropocentrism and psychological attributions is unexplored in previous research. These two studies also measured how anthropomorphism influences children’s anthropocentrism and attribution of psychological properties to other animals. Thus, the studies varied in terms of both the type of stimuli and the outcome measures, making it difficult to draw conclusions across this body of work about the impact of anthropomorphic pictures and language on both factual and conceptual learning about animals. Therefore, our second goal was to create carefully controlled experimental
stimuli featuring ‘animal selves’ (Mierek, 2010) that systematically vary in anthropomorphic language and pictures in order to make a better conclusion about the impact of media exposure on children’s factual learning and anthropocentric view of real animals.

Additionally, we aim to address an area of media use that has frequently been overlooked in previous research: the impact of parent-child engagement. Adults frequently use anthropomorphism even when engaging children in science activities. In previous research, we observed parent-child interactions at animal exhibits at two informal learning environments, a zoo and a science museum. While parents made more statements about the animals’ biological properties (e.g. eating, moving, growing, sleeping) to preschool-aged children than to school-aged children, they also made substantially more references imbuing animals with human social properties (e.g. thoughts, beliefs, emotions, social relationships, speech) to preschool-aged children.

Importantly, this was not driven by the child’s own interests, as children of both ages made these comments at similarly low frequencies (Geerdts, Van de Walle, & LoBue, under review b).

In addition to parents, teachers often use anthropomorphic language in preschool classroom science instruction. When asked directly, most preschool teachers reported that they did not believe that anthropomorphism was an effective method for teaching children about animals because it would lead to misconceptions (Kallery & Psillos, 2004). Despite their explicit concern, an analysis of teachers’ written lesson plans found that nearly every teacher used anthropomorphic language such as “plants love the sun because he helps them to grow”, “trees wake up in spring”, or even describing thunder as
a fight between clouds depicted with human faces (p. 304). Furthermore, observations of actual classroom interactions find that teachers not only frequently use anthropomorphism but also are the ones making the majority of anthropomorphic statements. Thulin and Pramling (2009) found that the teachers initiated 81% of anthropomorphic comments observed in a preschool classroom. Often, these comments distracted children from learning biological facts about the animals. Thulin and Pramling describe one case in which a child was interested in knowing about an insect’s diet, but the teacher continued to make anthropomorphic references to the animals “play” behavior rather than answering the child’s biological question. Again, little is known about the impact of this type of anthropomorphic language, both from media and from adults, on children’s biological or anthropocentric reasoning about animals. Thus, the results from the current research can help inform early education teachers and parents about the benefits or drawbacks of using anthropomorphic language to engage children in early science education.

To summarize, despite the prevalence of anthropomorphism in media, parent-child interaction, and school science activities, only a few studies have attempted to directly address its impact on children’s biological knowledge. Previous research comparing children from different cultures has argued that indirect exposure to anthropomorphic animals impacts children’s conceptual development, with little attempt to quantify children’s actual media exposure. Previous experimental research on children’s learning from anthropomorphic storybooks has varied widely in terms of the type of stimuli and the outcome measures, making it difficult to draw conclusions on the impact of anthropomorphic pictures and learning on both factual and conceptual
biological learning. Furthermore, these studies have ignored the additional parental input present in everyday parent-child interactions. Therefore, the current research aims to (1) quantify the use of anthropomorphism in children’s media and parent-child joint storybook reading (2) evaluate children’s exposure to and preference for anthropomorphic media, and (3) experimentally investigate the impact of anthropomorphism on children’s developing knowledge about real animals.

**Study 1**

Our first study focuses on quantifying the amount of anthropomorphism in children’s popular media today. The majority of content analyses on the presence of anthropomorphism in children’s media were conducted at least 10 years ago (e.g., Marriott, 2002; McCrindle & Odendall, 1994; Paul, 1996). The media landscape has changed rapidly over recent years, with an extreme increase in young children’s access to media. Technology has become increasingly affordably and as a result widespread, with over half (54%) of US households owning 3 or more televisions (The Nielson Company, 2009). Despite recommendations from the American Academy of Pediatrics (2011) that children younger than 2 years of age should avoid television use completely, recent parent surveys find that nearly half of infants under the age of two and over three quarters of preschoolers watch TV daily (Common Sense Media, 2011; Rideout & Hammel, 2006). Data from a large, national study found that 66% of their preschool aged sample exceeded the American Academy of Pediatrics recommended 2 hours of screen time (Tandon, Zhou, Lozano, & Christakis, 2011). Our own research previously found that parents reported that their infants were exposed to an average of 11 hours per week of television (Geerdts & LoBue, under review). Young children today have increased access
to this media in progressively more portable formats as well. A research survey of parents in the UK found that almost one third (31%) of children between the ages of 5 and 15 years watch TV on a device such as a computer or smart phone in addition to viewing on standard television sets. Despite these changes in format, television continues to be the most popular regular media activity for children (Ofcom, 2011).

Additionally, the proportion of child-directed media today is much higher than it was just a few years ago. In the past, children’s programming was limited largely to Saturday morning cartoons; today, multiple channels are dedicated to 24/7 children’s programming. Infant-directed media has become a multi-billion dollar per year industry, with families owning on average 5-6 infant-directed videos such as “Baby Einstein” and “Your Baby Can Read,” (Zimmerman, Christakis, & Meltzoff, 2007). The increasingly popular digital video recorder (DVR) allows parents to record and replay children’s programming at any time. A recent survey found that 65% of children between the ages of 5 and 7 years have a DVR in their home, compared to 53% just a year earlier (Ofcom, 2011).

Given the striking and rapid changes to media over the past few years, Study 1 was conducted to gain a more accurate picture of the amount of anthropomorphism found in popular US television shows geared towards preschoolers today. Additionally, we were interested in quantifying anthropomorphism in children’s television across educational and stylistic formats. It is possible that television designed specifically for educational purposes will be less likely to use anthropomorphism, given research that suggests that children are better able to generalize new information when there is a higher degree of similarity between the media and the real world object (e.g. Ganea, Pickard, &
DeLoache, 2008; Richert, Shawber, Hoffman, & Taylor, 2009; Simcock & DeLoache, 2006). Thus, we expect to find that anthropomorphism will be found more frequently in general audience shows than in educational shows.

**Methods**

Four popular child-directed television stations whose programming is primarily targeted to preschool-aged children were selected for analysis: PBS Kids, Disney Jr., Nick Jr., and Qubo. Within each station, all of their shows on air as of April 2011 listed as appropriate for preschoolers were selected, resulting in a sample of 75 television programs (see Appendix A for a full list of titles). Coding was based upon descriptions as well as video clips of the shows obtained from the network or show website.

**Coding.**

*Type of show.* All shows were categorized according to their main purpose: educational or “general audience” programs. Two criteria were used to judge if shows were designed for educational purposes:

1. Stated learning objectives: programs that list *specific* educational goals, such as problem solving, critical thinking, mathematical concepts, literacy skills, socio-emotional development, etc.

2. Educational and/or research staff: programs which listed having educational or research professionals on staff including Educational, Curriculum, and/or Research Advisors, Consultants, and/or Specialists

Descriptions of the shows from the network’s and/or program’s website were used to find stated learning objectives. Credits for the show and information listed on the network’s website were scanned for mention of educational and/or research staff members. Shows
that matched both of these criteria were coded as educational. “General audience” programs were any shows that did not fit both criteria. A second trained coder independently coded a randomly selected subset of 25 of the television shows to determine inter-rater reliability. Percent agreement between the coders was 84%. The primary coder reviewed any disagreements and selected a final code.

**Format.** The shows were classified as animated, live action, or combined. Animated shows were produced by any means of animation, including drawn cartoon and stop motion. Live action shows featured real-time actors and included humans and puppets. Combined shows featured aspects of both animation and live action either simultaneously or at separate times in the same program. A second trained coder independently coded a randomly selected subset of 25 of the television shows to determine inter-rater reliability. Percent agreement between the coders was 92%. The primary coder reviewed any disagreements and selected a final code.

**Subject.** The shows were then categorized as containing animals as central characters (i.e., at least one of the main protagonists was an animal) or as having no animal characters. The portrayal of the animals was then coded as realistic or anthropomorphic. Realistic animals were those that exhibited only natural, species-typical animal behaviors. Anthropomorphic animals were those that exhibited any human characteristics or behaviors, such as talking, walking upright, and wearing clothing. A second trained coder independently coded a randomly selected subset of 25 of the television shows to determine inter-rater reliability. Percent agreement between the coders was 92.3%. The primary coder reviewed any disagreements and selected a final code.
Results

Results are summarized in Figure 1. Many of the shows were educational. Forty-eight of the shows (64%) were classified as educational. With respect to the format of the shows, most shows were animated (73.3%) or combined animated and live action (10.7%) with very few being purely live action.

Close to two thirds of the shows, 51 out of 75, featured animals as central characters. All but two of those programs portrayed the animals anthropomorphically. One of those programs was a live action nature show, introducing children to real animals (*Animal Exploration with Jarod Miller*). The other was an animated cartoon in which the animal was the main character’s pet cat (*Caillou*). Overall, nearly all of young children’s television programming that featured animals as central characters portrayed them in a human-like fashion. Even some educational nature shows utilized anthropomorphism; one educational show designed specifically to teach preschool children about wildlife centers on a lemur that magically becomes a talking puppet when feed a special snack (an ability that real animals certainly lack) and helps introduce children to other animals in the forest (*Zoboomafoo*). The single most common type of children’s show is animated, educational shows with anthropomorphic animals, with 22 out of 75 programs falling into this category.

Chi-square tests of independence assessed the difference between educational and entertainment shows in use of either format or subject. Surprisingly, educational and entertainment shows did not differ significantly in the rate of either the presence of animals as main characters (*p* = .85), use of anthropomorphism (*p* = .66), or use of cartoon (*p* = .98).
Discussion

Our media analysis shows that animated, anthropomorphic animals are the most common type of shows in preschool children’s television. Contrary to our hypotheses, there was no difference in the amount of anthropomorphism featured in different educational formats. Given the prevalence of anthropomorphism in children’s television, it is critical that more research be directed at understanding the implications of these portrayals on children’s concepts of real animals.

However, television is not the only popular media format to which children this age are frequently exposed. Storybook reading is a common, if not daily, occurrence in many young children’s lives. In a recent large and representative media survey in the US, nearly all (91%) of children under the age of 5 have been exposed to storybooks, with the average age of first exposure at 5 months of age (Common Sense Media, 2011). Furthermore, 83% of children under the age of 6 read or are read to each day for an average of 48 minutes per day, with no significant difference in average amount of time among children as a function of family income (Rideout & Hammel, 2006). Thus, in the US reading is a nearly universal early media experience. Given that storybooks are so prevalent in children’s lives, our next study looked at the rate of anthropomorphism found in children’s storybooks.

Additionally, storybooks address a much broader range of topics than children’s television shows. Few of the educational shows we analyzed in Study 1 focused specifically on animals, science, or biology. One important aim of the current research is to understand whether anthropomorphism influences children’s ability to learn about
biology. Thus, in Study 2 we focused specifically on storybooks intended to teach children about *common biological properties*.

**Study 2**

Previous analyses of commercial storybooks find that mental state language (i.e., talking about cognitive states, emotions, desires, and morality) occurs quite frequently, nearly once every three sentences (Cassidy et al, 1998; Dyer, Shatz, & Wellman, 2000). Additional research finds that this is not unique to English language storybooks; Japanese storybooks were found to use mental state language at the same rate (Dyer-Seymour, Shatz, Wellman, & Salto, 2004). However, these studies looked at a wide array of general storybooks with many different topics. Do storybooks that feature animals and focus on biological properties similarly feature psychological information?

In Study 2, we analyzed the use of anthropomorphism and explanations of biological mechanisms in biology-oriented storybooks featuring animals as central characters that centered on three specific biological properties: property inheritance, contagion, and camouflage. We selected these topics because they are both popular ones in children’s literature and because they are often the focus of empirical research on children’s biological knowledge development.

Research on children’s developing understanding of these three phenomena has yielded mixed results with respect to whether or not children can provide appropriate and biologically specific causal explanations for each. For instance, the literature on inheritance uses a cross-species “adoption paradigm,” where 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 parent or adoptive parent on physical, behavioral, and
psychological traits (e.g., Bloch, Solomon, & Carey, 2001; Johnson & Solomon, 1997; Solomon, Johnson, Zaitchik, & Carey, 1996; Springer, 1996). 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 find that it is not until at least age 7 that children correctly favor the biological parent for physical resemblance but the adoptive parent for behavioral resemblance (e.g., Solomon et al., 1996). 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). Others argue that children’s failure to show this pattern is the result of lack of factual knowledge rather than an undifferentiated biological domain of reasoning (e.g., Springer, 1996; Springer & Keil, 1991).

The literature on children’s biological understanding of the process of contamination is similarly mixed. Classic research suggests that children do not have a biologically specific causal explanatory understanding of contagion, finding that even children as old as nine years were willing to accept immanent justice explanations such as the boy “got a cold because he disobeyed his mother” (Kister & Patterson, 1980, p. 841). Similarly, Bibace and Walsh (1981) found that explanations provided by children under seven are largely based on superstition and magic. However, other researchers argue that the interview methodology used by these researchers failed to accurately assess children’s understanding. Newer research finds that although they may not have a full understanding of the biological mechanisms that cause illness (i.e., germs), they are more likely to endorse contamination and contagion as causes of illness than psychological
mechanisms such as wishing or bad behavior (Kalish, 1996; Siegal, 1988; Springer & Ruckel, 1992).

Despite extant research on children’s understanding about these biological properties, little research has focused on possible sources of knowledge. In the current study, we ask whether storybooks with animal characters provide causal explanatory information about biological properties? Additionally, do they provide biological or psychological explanations? Thus, a major goal of Study 2 is to examine whether children’s biological storybooks with animals provide a potential source of information for the development of sophisticated biological knowledge. To directly compare how the storybook information relates to children’s own understanding of these properties, we adapted the coding schemes used in the experimental literature to code children’s own explanations. Illustrations in storybooks about cross-species adoption, for example, may provide evidence for physical resemblance to biological parents and behavioral resemblance to adopted parents. Additionally, the written narrative may provide explanations for why inheritance of physical and behavioral properties differs by contrasting inheritance or origins with shared experiences. However, they may also fail to provide such information. The use of anthropomorphism, in particular, may lead to a focus on human psychological mechanisms, such as family bonds and emotional ties. We may find that the types of explanations commonly present in these storybooks resemble the explanations used by children in previous research.

Based on our findings from Study 1 as well as previous storybook analyses, we expected to find significant anthropomorphism as well as psychological causal mechanisms in children’s storybooks. We did not expect to find extensive use of
biological causal mechanisms in children’s commercial storybooks; anthropomorphism should further reduce the use of biological causal mechanisms (e.g., germs) and increase the use of psychological causal mechanisms (e.g., desires and intentions).

**Methods**

One of the largest online book retailers, Amazon.com, was used to gather a list of storybooks for each of the three topics. Broad keywords were used to search book descriptions and produce an initial sample, specifically “adoption”, “camouflage”, “illness” and “contagion”. We then applied limiters to restrict our search to English-language children’s storybooks for a preschool audience (ages 3-6). Storybooks were scanned for content to be sure that they fit our limiters, were designed for a general audience (i.e., we excluded religious storybooks, storybooks created specifically for adopted children, and storybooks aimed to helping children overcome their fear of the doctor), and featured animal main characters. All appropriate storybooks were then collected from university and local lending libraries. Any books which were out of print or which we were unable to obtain were excluded from analysis (1 illness book and 10 camouflage books). These books were coded resulting in a final sample of 20 adoption, 25 illness, and 39 camouflage books (see Appendix B for full list of titles and authors).

**Coding.** All of the storybooks were analyzed and coded for (1) use of anthropomorphism and (2) explanations/mechanisms regarding each biological property.

**Anthropomorphism.** Both the language and pictures in each book were coded for use of anthropomorphism. Each book was placed into one of four categories:

1. Realistic Pictures & Realistic Language
2. Realistic Pictures & Anthropomorphic Language
As in the first study, animals were considered anthropomorphic if they exhibited human motivation, characteristics, or behavior. Images were considered anthropomorphic if they depicted animals as engaging in human behaviors (e.g., living in a house, reading, walking upright, wearing clothing, etc.). Language was considered anthropomorphic if it used an intentional framework to describe the animals’ behavior (Ganea et al., 2011) or if the animals were depicted as speaking or thinking either explicitly through direct speech or implicitly through narration. Realistic language used neutral, factual language to describe or explain the animal’s behavior without implying underlying mental states.

Two trained coders independently coded all of the storybooks. Percent agreement between the coders was 92.7% (Cohen’s $k = .883$). The primary coder reviewed any disagreements and selected a final code.

**Biological Mechanisms.** 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 three biological properties.

For the adoption stories, the text of each storybook was coded for reference to specific physical and behavioral similarities and differences between offspring and their biological and adoptive parents based on 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 non-physical (i.e., beliefs, emotions, preferences, activities) traits. Comments about specific family and/or child 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, regardless of being biologically factually correct (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 (e.g., “John didn’t look like all his sisters”).

- **Biological Family Resemblance:** A general statement that either compared or contrasted biological family members regarding resemblance on specific properties.

- **Generic References to Category Membership:** An explicit statement that the individual’s membership in a specific kind category determines or causes the property For example, “Cats drink milk” was coded as a generic category statement but “The Smith family likes to drink milk” was coded as a statement appealing to resemblance to the adoptive family.

Additionally, for non-physical properties only, the following two codes were added:

- **Shared Social Activities (Adoptive):** A social activity shared with the adoptive family members (e.g., “they played hopscotch together”).

- **Shared Social Activities (Biological):** A social activity shared with the biological family members.
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 physical/medical origin for the illness.
- **Physical Proximity**: This code was employed if the story either explicitly or implicitly mentioned physical proximity as a possible cause; for instance, a story where a character took care of one character who was sick and then themselves became sick with no reference to any other mechanism was coded as providing a physical proximity mechanism.
- **Behavioral**: Any specific activity or behavior which led to the child getting sick, such as not wearing a coat or eating too much junk food.
- **Psychological**: Any psychological or magical cause that led to getting sick, such as wishing to be sick, witchcraft, or as punishment for behaving badly.
- **Unspecific/No explanation**

For the camouflage stories, the coding scheme focused on the type of explanation provided for the animal’s ability to hide from predators or other animals. Prior studies have looked at children’s understanding of camouflage as a psychological (based on the
animals needs and desires) versus physical adaptation (Legare et al., 2013; Ganea et al.,
2011). Our coding scheme included:

- **Evolutionary**: any reference to the animal’s physical camouflage as the result of
  an evolutionary adaptation (e.g., “the frogs evolved to fit their environment”).

- **Physical (No explanation)**: any references about the physical properties without
  giving a cause (e.g., “the frog is the same color as the grass making him hard to
  spot”).

- **Need-based (Teleological)**: includes the following terms: need to, had to, so that,
  so they could, in order to, etc. (e.g., “the frog matches the grass so he won’t get
  eaten”).

- **Desire-based (Psychological)**: includes reference to mental states using the
  following terms: wanted to, liked to, wished to, hoped to, liked to, decided to,
  thought about, etc. (e.g., “the frog wanted to hide from the bird”).

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 receive more than one code. Two trained coders
independently coded all of the titles. Percent agreement between the coders was 84.5%
(Cohen’s $k = .55$) for the adoption stories, 81.5% (Cohen’s $k = .74$) for the illness stories,
and 64.1% (Cohen’s $k = .451$) for the camouflage stories. These kappas all indicate a fair
to good level of agreement (Fleiss, 1981). The primary coder reviewed any disagreements
and selected a final code.

**Results**
Anthropomorphism. Results are summarized in Table 1. None of the cross-species adoption storybooks used realistic or factual language; all of the stories used anthropomorphic language to describe the animals as possessing complex feelings, emotions, behaviors, and 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%) visually portrayed the animals 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 be due more to the nature of the story than a desire to represent animals naturally. 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 visually portraying them all as “humans.”

Similarly, none of the illness storybooks used realistic, factual language; rather, all used anthropomorphic language. Additionally, nearly all of the illness books (96%) used anthropomorphic drawings. Illness books were significantly more likely to use anthropomorphic drawings than the adoption books, \(X^2(1, 45) = 5.72, p = .017\). 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”.

In contrast, all of the camouflage storybooks used realistic drawings or photographs of animals. Additionally, most (77.5%) used factual language to describe
camouflage rather than anthropomorphic language. Overall, storybooks with an adoption or illness theme were very different from storybooks with a camouflage theme. As expected, adoption and illness storybooks used animals to tell a very “human” story. However, unexpectedly, camouflage storybooks used realistic animal depictions to factually describe a physical, biological property. We did not expect to find such a striking difference between the camouflage stories and the similar adoption and illness stories.

**Biological Mechanisms.** None of the adoption storybooks contained any reference to the biological mechanisms of inheritance for either physical or behavioral properties. For physical properties, storybooks provided explanations based on biological (30%) and adoptive family resemblance (50%) or generic category reference (30%). For behavioral properties, storybooks also used adoptive family resemblance (40%) and generic category references (45%) but most frequently referred to shared social activities with the adoptive family (75%). Additionally, all books referred to mechanisms for the transmission of behavioral properties, compared to only 60% of books referring to mechanisms for physical properties. Overall, children’s commercial storybooks do not focus on biological inheritance, focusing most often on behavioral properties and shared social activities.

Similarly, most illness storybooks (92%) failed to provide the correct, biologically specific causal mechanism underlying the phenomenon of contagion. No storybooks specifically mentioned germs but two did mention physical medical causes, including tonsils and needing an operation to ‘fix a stripe that slipped out of place.’ Many stories implied that physical proximity contributed to the transmission of illness (36%), but none
of these referenced actual physical mechanisms of transmission such as germs. In many stories, a character got sick and then the character that was their 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 passed between individuals, but just that physical proximity was a possible factor. Few stories mentioned psychological (8%) or behavioral causes (12%) for illness. Most often, stories did not mention any possible mechanisms for illness (40%) and simply focused on the experience of being sick.

Like the illness and adoption stories, few camouflage stories presented a biologically sophisticated causal explanation or mechanism for the animals’ appearance. Instead, many (33.3%) merely stated the animals’ physical resemblance to their surroundings. When they did present an explanation, very few (5.1%) mentioned evolution or adaptation. Sometimes the storybooks provided a teleological explanation (20.5%) based on the animal’s need to blend in but more often they provided a desire-based reason (41%) appealing to the animal’s own desires to blend in to avoid predators or hunt prey. Even though few storybooks were explicitly anthropomorphic (especially in pictures), they still often provided an explanation for biological processes based on mental states and intentions.

Discussion

Overall, the adoption and illness storybooks most frequently employed animals as human stand-ins; within these stories animals are almost always portrayed anthropomorphically in both pictures and language. Additionally, 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
germs. In the canonical adoption story, “family” is defined by emotional and social bonds and not by heredity. Similarly, illness stories often focused on the physical and emotional consequences of being sick and often presented physical proximity as an important factor in predicting contagion. This may help explain why children themselves do not always reason according to specifically biological causal mechanisms in similar adoption and contagion paradigm tasks. Interestingly, however, illness storybooks did not frequently provide incorrect psychological causal explanations, such as citing illness as punishment for doing something wrong or immoral as some have found that children appear to be willing to do (Bibace & Walsh, 1981; Kister & Patterson, 1980).

On the other hand, the camouflage storybooks portrayed animals realistically, especially in pictures. All of these animals were presented in natural habitats, often with actual photographs. The differences we observed in the levels of explicit anthropomorphism across the three kinds of books likely reflect the purposes for which the books were written. The adoption and illness storybooks used animals to tell a uniquely human story revolving around emotions and intentions even though the topics of the books were fundamentally biological properties, whereas camouflage is more commonly thought of as a survival mechanism most prevalent in and relevant to non-human animal species. In fact, only one camouflage storybook explicitly likened camouflage to humans by showing a person hiding with camouflage gear on. Even though camouflage books appeared more realistic than adoption or illness books, they still often used psychological, intentional language to explain the animal’s behaviors; 60% of the storybooks provided psychological or teleological explanations for camouflage based on the animal’s desires, intentions, or needs. Overall, the authors of
camouflage books may use realistic animals because it is a topic that is seen as animal specific, while the authors of adoption and illness books intend to teach children about humans but use fantasy animals as human “stand-ins” to increase children’s interest in the books (Parker & Lepper, 1992).

These biological properties were specifically selected because of their use in prior studies of children’s general biological knowledge development. Cross-species adoption and contagion paradigms are frequently used to measure the sophistication of children’s naïve biology. However, as it relates to animals specifically, the causal information that children are receiving from both televised and print media sources is often not specifically biological. The incorrect, psychological causal information that children are receiving from storybooks mirrors some of the incorrect, psychological causal reasoning that children have been shown to use in prior research (e.g. Solomon et. al, 1996; Johnson & Solomon, 1997; Kister & Patterson, 1980; Bibace & Walsh, 1981). Thus, it is important for researchers to consider these and other common experiences in children’s lives that may be impacting their biological knowledge development.

Study 3

The television shows and storybooks analyzed in our first two studies were selected primarily because of the popularity and wide availability of these media formats. However, that these formats are widely available does not necessarily entail that children in fact consume these media sources at high rates. Children and parents can choose to avail themselves of any type of media, and it is important to gather information on what families are selecting to be sure that our results are reflective of children’s actual media exposure. Perhaps children are more heavily selecting anthropomorphic media than the
proportions we found suggest. On the other hand, some parents may actively monitor their children’s media use, selecting only realistic, scientific, or educational media for their children. Thus, to capture a more accurate picture of children’s actual daily exposure to anthropomorphic media, our third study collected parental reports on their children’s exposure to and preferences for media in multiple formats.

**Methods**

**Participants.** Self-report data was collected from parents of 80 children between the ages of 3;0 and 6;7 years of age ($M = 4;7$). A median split was performed and data was compared separately for younger ($N = 40, M = 3;9$) and older ($N = 40, M = 5;5$) children. Families were recruited through a participant database of interested parents as well as through local preschools. Parents were contacted by phone, email, or a letter sent home with their child and invited to complete our survey. Participants lived in suburban communities within the New York metropolitan area. The sample was predominantly Caucasian (57.5%), but the sample also included Asian (13.75%), Black (2.5%), Hispanic (5%), and Mixed Race (8.75%) participants. An additional 12.5% of families declined to disclose ethnicity information. The majority of participants came from middle class families, and 83.1% of parents had attained a college degree or higher.

**Procedure.** Parents were asked to estimate the amount of time their child spends per day using various media types including TV and videos, books, and video and computer games. They were also asked whether they have any rules that govern their child’s media usage (e.g., only with a parent present, daily time limits, content restriction, etc.). Additionally, parents were asked to list their child’s favorite movies, TV shows, and books. Parents were permitted to ask their children directly about their preferences if they
had trouble answering any of the questions. Parents were not told about our interest in anthropomorphic media or prompted in any way to report on specific genres prior to filling out the survey.

Coding. Responses were transcribed and all responses were reviewed for valid titles (for instance, some parents merely put “books about trucks” or “ABC books” which were not included in analyses). These titles were then coded for anthropomorphic central animal characters using the same criteria as Study 1. Movies and television shows were combined for these analyses and are referred to collectively as “screen media”. Two trained coders independently coded all of the titles. Percent agreement between the coders was 87.1%. The primary coder reviewed any disagreements and selected a final code.

Parents’ reported media rules were divided into time restrictions (e.g., only before bedtime, max 30 min per day, etc.), content restrictions (e.g., no violent TV, only educational programming, etc.), and parental control/monitoring (e.g., parent must be present, parent preselects shows, etc.).

Results

Parents listed a total of 245 valid book titles and 422 valid screen media titles (see Figure 2). The majority of children’s favorite screen media (64.9%) featured anthropomorphic animal characters. In our analysis of television shows in Study 1, we found that 65.3% contained anthropomorphic animals, suggesting that our sample was highly representative of children’s actual media exposure. The percentage of children’s favorite books that were anthropomorphic was highly similar to their favorite screen media (66.5%).
A 2 (age: young, old) x 2 (media: screen, book) mixed-groups factorial ANOVA with age as a between subjects factor was used to determine whether the proportion of anthropomorphic media within children’s preferences differed for older and younger children among books and screen media. There was no significant difference in proportions of anthropomorphic between books and screen media and no significant interaction between age groups and media type, all $p > .44$. However, there was a significant difference in proportion of anthropomorphic media within children’s preferences between older and younger children, with younger children’s preferred media in general ($M = 0.72$, $SD = 0.28$) containing significantly more anthropomorphism than older children’s ($M = 0.60$, $SD = 0.26$), $F(1,64) = 6.67$, $p = .012$. Thus, in general, younger children are more likely to prefer anthropomorphic media than older children.

Parents reported that their children spend close to 3.5 hours per day using media. Most parents reported that their children read (96.3%), watch screen media (88.8%), and play computer and video games (70.0%) each day. For children who are exposed to these media forms, parents estimated that their children spend an average of 104 minutes per day watching screen media, 59 minutes per day reading, and 45 minutes per day playing video or computer games. A 2 (age: young, old) x 3 (media: screen, book, computer/video games) mixed-groups factorial ANOVA with age as a between subjects factor was used to determine whether the time spent with media differed for older and younger children. Overall the effect of media type on time per day was significant, $F(2, 78) = 24.56$, $p < .001$. Pairwise comparisons reveal that children spent significantly more time watching screen media than reading and significantly more time with either screen media or books than playing video games, all $p < .001$. Surprisingly, overall amounts of
media usage did not differ between younger and older children, $p = .916$. Additionally, there was no significant interaction effect between age and media, $p = .721$.

Parents were also asked to report whether their family had any rules governing their children’s media use. Only 12 parents reported not having any specific media rules. Forty-four parents reported having time restrictions, 21 parents reported having content restrictions, and 30 reported parental control/monitoring. Separate chi-square tests were used to test whether parents were more likely to use any type of rule for younger or older children. There were no significant differences in use of any type of restrictions between younger or older children, all $p > .45$. Additionally, we were interested in seeing parental control resulted in different proportions of anthropomorphic media preference. A 2 (age: young, old) x 2 (media: screen, book) x 2 (rules: media rules, no media rules) mixed-groups factorial ANOVA with age and media rules as a between subjects factor revealed no significant differences in anthropomorphic media preferences based on presence of parental rules, $p = .501$. Furthermore, there was no significant interaction with age, $p = .159$. Similarly, a 2 (age) x 2 (media) x 2 (rules) ANOVA on time spent per day with media revealed no significant differences based on rules ($p = .112$) and no significant interaction with age ($p = .978$). Thus, degrees of preference for anthropomorphic books or screen media as well as amount of media exposure did not differ for either age group as a function of parental media consumption rules.

Discussion

Overall, the data from Study 3 supports the media analyses in Studies 1 and 2. Nearly two-thirds of children’s favorite screen media programs use anthropomorphism, the same proportion that we found when analyzing a sample of programs. While older
children’s favorite screen media programs are less likely to contain anthropomorphic animals than younger children’s favorite programs, no such difference was found within books favored by younger and older preschool children. Parents also report that their children spend a substantial amount of time each day with these books, TV shows, and movies; children as young as 36 months are exposed to close to 3.5 hours of media per day. This further supports the need for detailed analyses of the content of these frequent experiences in children’s lives. Despite many parents’ reporting having rules and restrictions governing their child’s media exposure, there was little differences in the amount of media exposure or preferences for anthropomorphic media between children whose parent’s reported having rules and those who didn’t, suggesting that experiences with anthropomorphic media are fairly consistent across a wide array of children.

In our first three studies, we found a high degree of anthropomorphism across different forms of children’s media, with little biological causal explanatory information. We also found that preschool-aged children prefer this type of media. However, simply examining the content of the media alone leaves out an important aspect of media consumption: *joint engagement*. As we found in this study, parents often report only letting their child watch television or use the computer when a parent is present. How does the presence of a parent change children’s media experiences? Do parents provide additional information that may impact learning from media? It is important to look further at parent-child interaction during media use and the possible additional information that parents provide.
Study 4

Although we know that media use, especially storybook reading, is an incredibly common occurrence for young children, it is important to remember that they are often sharing this experience with others. Parents and children frequently share in joint media engagement (JME): multiple people viewing, reading, creating, or playing with any form of media together. JME can reduce some of the negative effects of media exposure by constraining the content and frequency, increasing enjoyment, and enhancing the pedagogical effects of educational media. Because of the positive effect, many children’s movies and television shows encourage co-viewing by adding material to keep older siblings and parents engaged such as humor, popular culture parodies, and celebrities (The Joan Ganz Cooney Center, 2011).

Many studies have found positive effects of parent-child joint storybook reading on children’s cognitive outcomes, especially within early literacy skills and school achievement. Direct studies as well as meta-analytic literature reviews reveal a positive relationship between frequency of parent-child joint book reading and children’s language development, emergent literacy skills, and early reading skills (e.g., Bus, de Jong, & Van Ijzendoorn, 2007; Hindman, Connor, Jewkes, & Morrison, 2008; Senechal, & Young, 2008). Additionally, specific parental reading styles have been found to be important for children’s literacy development. In a study of parent-child storybook reading with 2-year-olds, high parental sensitivity, positive regard, and stimulation of cognitive development was related to the child’s greater focus, enthusiasm, and positive mood during reading (Frosch, Cox, & Goldman 2001).
Considerably fewer studies have focused on parental reading styles and the impact on specific knowledge content, such as biological or science learning. Research has shown that parental involvement in specific disciplines impacts children’s later achievement and interest in these areas. For instance, parents’ early promotive behaviors, such as purchasing science-related toys and becoming involved in their child’s math and science activities, predict children’s later interests and involvement in math and science activities (Jacobs & Bleeker, 2004). Another longitudinal study found that mothers’ use of science talk with their children predicted their child’s reading comprehension for science-related material two years later (Tenenbaum, Snow, Roach, & Kurland, 2005). Snow & Kurland (1996) argued that parental discussion of scientific processes in science-related parent-child activities prepares children for later school science discussions, making early parent-child science interaction an important area of focus for increasing school science achievement. Science related storybook reading in classrooms can also impact children’s science knowledge development. Gonzalez et al., (2011) found that implementing a science-focused shared storybook reading intervention in Head Start preschool programs increased children’s receptive and expressive science-related vocabulary.

Given the demonstrated relationship between early experiences and later knowledge development, the current study looks at how parents engage their children in storybook reading about biological properties. We chose to focus on one of the biological properties we previously analyzed in children’s media: cross-species adoption. We chose this property specifically because children and parents most likely have less experience with books about cross-species adoption than illness. Also, while camouflage is more
clearly a biological construct, stories about cross-species adoption feature strong biological and psychological components, maximizing our chances of capturing conversations of both types between parents and children. We created a wordless storybook that resembled commercial cross-species adoption storybooks to investigate the nature of the information parents spontaneously provide about biological inheritance and whether this information is similar to or different from that provided in commercial storybooks. We also measured children’s own understanding of animals’ possession of specific biological and psychological properties.

Similar to the commercial storybooks, we did not expect to find many biology specific causal explanations in parental speech. Previous research finds little evidence of explicit causal explanations in child-directed speech even within learning environments. In our own research on parent-child conversation at a science museum exhibit on animal camouflage, we found that parents rarely provided causal explanations about camouflage. Even though 92% of families mentioned the visual property (“these stick bugs look like sticks!”), only 29% of parents talked about why these bugs look like sticks (“So you probably wouldn’t try and eat this bug because you would think it’s a stick if you just flew by real quick”). It was even more surprising given the fact that large signs next to the animal tank provided this information for parents (Geerdts et al., under review b). Similarly, Crowley et al., (2001) found that only 31% of parents provided a causal explanation during joint engagement at a science museum exhibit. Given that these interactions occurred in science-focused learning environments, we expect to find similarly low instances of causal explanations in parent-child interaction during storybook reading. Consequently, we do not expect to find that children themselves will
provide sophisticated, biological causal mechanisms when asked about various biological properties of animals. We also expect that they will be highly likely to apply psychological properties to animals of the same species as the character in the storybook, as has been found in previous research (Ganea et al. 2014).

Methods

Participants. Eight dyads of parents and their preschool-aged children (5 girls; age range: 3;4-4;10, $M = 4;0$) participated. Families were recruited through a participant database of interested parents. Parents were contacted by phone or email and invited to participate. All participants took part in the study at the Infant Cognition Center at Rutgers University. Participants lived in suburban communities within the New York metropolitan area. The sample was predominantly Caucasian (50%), but the sample also included Asian (25%), Black (12.5%), and Hispanic (12.5%) participants. Most parents (84.6%) had attained a college degree or higher. Occupation data was missing for 18.8% of parents. Of those who responded, most parents held professional and related occupations (69.2%) and 15.4% of parents reported being full-time stay at home parents.

Materials.

Picture Book. The cross-species adoption book was created using Adobe Photoshop. The book (8½” x 11”) consisted of 23 pages. The majority of the storybook was wordless, with the exception of short speech bubbles ($M = 4$ words, Range: 1-8) on 9 key pages to provide a basic story line for parents (see Appendix C for sample pages). The storybook, entitled “Chester Finds a Family,” was modeled after the collected commercial storybooks. In the story, a baby monkey goes to live with a cat family. The monkey is shown engaging in activities typical of cats such as drinking milk. When the
monkey realizes that he does not look like the rest of his family, he decides to “find a family that looks just like [himself]”. On his way, he compares himself to many other animals until he finally finds his monkey family. The monkey is shown engaging in activities with his monkey family such as eating bananas and swinging in the trees. However, each activity with the biological monkey family is compared with a thought bubble of his previous activities with the adoptive cat family. The last page ends with Chester thinking of both families with the caption, “What do you think will happen?”

*Post-Test.* Following the story, the child was asked various questions about the biological and psychological properties of monkeys to see what children know and think about animals (see Appendix D for full list of questions). All questions were asked about monkeys generally with no mention made to Chester or the storybook during this phase. The biological properties we asked about included sleeping, internal organs, growth, eating, contagion, and parentage. The psychological and social properties included communication, friendship, and emotions.

**Procedure.** After completing the informed consent, parents and children were seated near each other at a table in a way that was comfortable to both the parent and child. The parents were then given the storybook with the following instructions:

“This is a wordless picture book about a monkey named Chester who was adopted by cat parents when he was little. As Chester spends time with the cat family, he begins to question himself and goes on an adventure to find the monkey parents who gave birth to him. We would like you and your child to make up the story in whatever way you would like. Feel free to say anything you want, but please read through each page with your child!”

The experimenter then left the room and allowed the parent and child to spend as much time as they wanted reading the book together. When they were finished, the experimenter came back into the room and invited the child to play a game with her. The
child was told that the experimenter wanted to learn about monkeys and needed the child’s help in answering the experimenter’s questions about monkeys. The experimenter then proceeded to administer the post-test. Upon completion, children were rewarded for participation with a small toy and certificate.

Coding.

*Storybook Reading.* Parent-child interaction was recorded and later transcribed verbatim. Parent-child speech was coded using the explanation/mechanism scheme from Study 2. This coding scheme focused on the possible causal mechanisms for the animal’s possession of specific physical (i.e., bodily characteristics) and non-physical (i.e., beliefs, emotions, preferences, activities) properties: biological inheritance, family resemblance, generic category references, and shared social activities. Using the same coding for parental speech as we did for the commercial storybooks in Study 2 allowed us to directly compare the use and frequency of these mechanisms in commercial media to parental speech.

*Post-test.* Children’s answers were recorded and later transcribed verbatim. Responses were coded based on whether they reflected a full, biological understanding of the property (score of 1) or an incorrect or psychological understanding of the property (score of 0). For instance, for the question “What would happen if a monkey didn’t eat for a long time?” a correct/biological answer would be “he would die” whereas an incorrect/psychological answer would be “He would be sad.” Two trained coders independently coded all of the transcripts. Percent agreement between the coders was 90.4% (Cohen’s $k = .85$). This kappa indicates an excellent level of agreement (Fleiss, 1981). The primary coder reviewed any disagreements and selected a final code.
Results

Storybook Reading. Results are presented in Table 2. Like the commercial storybooks, no parents provided any information about the causal mechanism of biological inheritance for either physical or non-physical properties. Additionally, both commercial storybooks and parents focused more heavily on non-physical and behavioral properties than physical traits. In study 2 we found that all of the books mentioned mechanisms for possession of non-physical properties whereas only 60% mentioned mechanisms for possession of physical properties. Similarly, a paired-samples $t$-test revealed that parents made significantly more statements related to activities and non-physical properties ($M = 13.50$, $SD = 7.82$) than physical properties ($M = 2.75$, $SD = 2.60$), $t(7) = -3.75$, $p = .007$.

For physical properties, parents often provided explanations based on biological (62.5%) and adoptive family resemblance (75%) and occasionally generic category references (25%). Chi square comparisons revealed no significant differences in use of any of these three categories between parents and commercial storybooks in Study 2, all $p > .200$.

For behavioral properties, like the commercial storybooks, parents most frequently referred to shared social activities, with either the adoptive (100%) or biological family (87.5%). Chi square comparisons revealed that parents mention shared social activities with the biological families significantly more than the commercial storybooks in Study 2, $\chi^2 = (1, N = 28) = 8.27$, $p = .004$. However, this may be because our storybook included the biological family whereas not all of the commercial adoption storybooks did.
Parents provided explanations for commonalities in behavioral properties based on adoptive family resemblance (37.5%), biological family resemblance (25%), and generic category reference (75%) at similar rates to the storybooks. Chi square comparisons revealed no significant differences in use of any of these three categories between parents and commercial storybooks in Study 2, all \( p > .132 \).

Overall, the information parents provided was highly similar to the storybooks we analyzed in study 2, with no focus on inherently biological causal mechanisms and much more focus on shared social experiences that tie families together.

**Post-test.** Children knew the correct answer to only a few biological questions; 100% of children knew that monkeys sleep, have bones inside their bodies, and eat bananas. Most children (87.5%) also knew that monkeys breathe, grow, have monkey parents, and give birth to other monkeys. Children also consistently failed to answer some questions correctly; no child was able to give a correct, biological answer to what would happen if a monkey went a long time without eating or why you may or may not be able to get (or give) a cold from a monkey you played with. Most of children’s answers about not eating for a long time revolved around the size of the monkey, that he would either get smaller or he would not get any bigger, and no child said that he would die. For illness transmission, even though 62.5% of children said that you can’t get a cold from a monkey, most children justified their answer by appealing to desires (“because I don’t like getting colds”), behaviors (“because I have a jacket”), or location (“There’s no monkeys around me here!”).

Children had considerable difficulty with many of the other biological questions that requested explanations or predictions, such as “why do monkeys sleep?”, “what
makes monkeys grow?”, and “what would happen if a monkey ate people food?” The one explanation question to which most children responded by providing a biological cause was “Why do monkeys eat?”. Children reported that monkeys eat because they are hungry or because it helps them grow. Only one child mentioned a psychological cause, saying, “‘cause they like to.” Presumably this was easier for children to answer because they themselves have experienced hunger and have frequently been told to, for instance, eat their vegetables so they will grow big and strong.

Most children correctly said that monkeys can’t talk (75%) and that when they do make noise we can’t understand what they are saying (83.3%). However, 3 out of 8 children did think that a monkey would be able to understand you if you talked to them. Six out of 8 children also thought that monkeys have “friends.” Interestingly, nearly all (87.5%) of children thought that monkeys can feel happy, but very few children were willing to attribute negative emotions such as feeling sad (25%) and angry (14.3%) to monkeys.

Discussion

We conducted this study to understand more about the input provided by parents in storybook reading about animals’ possession and transmission of biologically relevant properties, specifically in the context of a cross-species adoption story. Limited research has focused on the impact of reading strategies on specific knowledge content, such as biology or science learning. This storybook was created to reflect the content generally available in commercial storybooks in order to capture a realistic picture of parent-child storybook reading.
Overall, we found that parents, like commercial storybooks, focused more heavily on social and behavioral properties than physical traits in telling a story about cross-species adoption. Taken together with study 2, our results suggest that neither commercial storybooks nor parent-child interactions about adoption provide a ready source of sophisticated information about biological, causal mechanisms of inheritance. Simple resemblance and shared activities is the leading explanatory mechanism provided by both storybooks and parents. This may help explain why children themselves do not always reason according to specifically biological causal mechanisms in similar adoption paradigm tasks. For instance, we found that children were largely unable to provide explanatory information about these properties, such as why colds are contagious, why animals sleep, and what happens when an animal doesn’t eat. Thus, it is important for future research to investigate other potential information sources of biological information and measure their direct impact on knowledge development.

However, this study was limited in scope, presenting just one type of storybook. We provided parents with an anthropomorphic storybook, showing cats that live in houses and monkeys that can write letters about a human-specific social experience, adoption. Although we used this theme to mirror a commonly employed experimental paradigm, it may have biased parents to treat the animals as human surrogates and focus less on biological inheritance and more on psychological and behavioral aspects of family membership. Additionally, the use of an interview methodology with children may not accurately reflect their understanding. For instance, many children were unwilling to provide answers to questions that went beyond a simple “yes” or “no” response, often saying “I don’t know”; it is unclear whether these children do not know the answer or
simple do not want to answer. Some researchers argue that children’s explicit answers may not reflect their true understanding, and that children even answer questions without understanding them (e.g., Pratt, 1990; Waterman, Blades & Spencer, 2001).

Importantly, since we were limited to a small sample in this study and only one type of storybook, we were unable to look for a direct connection between the content of parent’s speech and children’s post-test answers. Thus, in order to draw a better conclusion about the impact of anthropomorphic language and/or pictures in children’s media on children’s biological and psychological understanding of animals, in Study 5 we used an experimental methodology to manipulate exposure to anthropomorphic media.

**Study 5**

Studies 1-4 provided a comprehensive examination of the content of children’s daily experiences with anthropomorphic media. Across studies, we consistently found that neither the content of children’s storybooks themselves nor the additional information that parents introduce when reading these books to their children generally provide a ready source of sophisticated information about biological properties. Instead, both sources frequently introduce these processes with a psychological, intentional framework. However, none of these studies provide direct insight into the effect of these experiences on children’s biological and psychological knowledge about animals as well as their learning about the biological properties. Thus, in the final study, we will directly examine the efficacy of using anthropomorphism within a context meant to teach children about animals’ biological properties by systematically manipulating the amount of anthropomorphism in storybooks about another biological property: camouflage.
Previous research has demonstrated that a period of significant revision of knowledge of both plants and animals occurs between 3 and 5 years of age (e.g., Hickling & Gelman, 1995; Rosengren, Gelman, Kalish, & McCormick, 1991). Thus, for the current study, we targeted 4–year-olds as they are in the middle of this transition period and may be most highly interested in and robustly influenced by novel biological information. Additionally, previous research suggests that although they often know something about biological phenomena that they themselves have experienced, such as illness and growth, children at this age know little about camouflage. At pre-test, Ganea and colleagues (2011) found that 4-year-olds were at chance (54.4%) for picking which of two animals (camouflaged vs non-camouflaged) was more likely to get eaten by a predator. Furthermore, those children that did choose the correct animal never explicitly provided an explanation based on camouflage. Also, children at this age are beginning to display important pre-reading skills, such as writing letters and reading simple words (Wolfe & Nevills, 2004). Thus, a storybook reading task is highly reflective of their everyday experiences with storybooks.

Two prior studies have looked at children’s transfer of learning about camouflage from storybooks to novel animal characters and, in one of the studies, to real-life animals. Brown & Kane (1988) looked at 3-year-olds’ ability to transfer novel information across novel analogical problems. In one set of studies, they presented children with novel information about animal camouflage and mimicry and measured their ability to transfer solutions across similar problems (e.g., “How could the caterpillar stop the big bird that wants to eat him?”). They found that many 3-year-olds (61%) explicitly mentioned the problem similarity across scenarios and close to 75% correctly solved the new problem
using information from the previous problem. Furthermore, they performed significantly better in the animal condition than in a similar condition that instead involved transferring novel uses of familiar tools to solve a problem (e.g. stacking tires on top of each other to reach an item high on a shelf without a ladder) across similar problems. The authors suggested that novel biological information about animals might be particularly interesting to children, increasing their ability to transfer knowledge to new problems. This study suggests that even very young children may show high degrees of transfer of knowledge learned in storybooks to other similar situations with animals. However, this study was did not address the role of anthropomorphism and presented the information to children using factual language.

Additionally, Ganea and colleagues’ (2011) findings suggest that anthropomorphic media should be just as effective at teaching children novel biological information about real animals as factual media. However, a major limitation to the application of these results to children’s everyday experiences with anthropomorphic media is that they only manipulated anthropomorphism within the language, pairing the storybook with real photographs. This close visual match between the symbolic media and the real life examples may have facilitated children’s transfer of biological knowledge between the story-book and real-life animals. Prior studies have shown that even infants are able to transfer knowledge from media to the real world when the referents share a high degree of visual similarity (e.g., Ganea et al. 2008). Indeed, the addition of anthropomorphic pictures in a follow up study lead to a decrease in generalization of factual properties from anthropomorphic storybooks to real animals (Ganea et al. 2014). Thus, in the current study, we created storybooks that use both
anthropomorphic language and images in order to more accurately reflect commercial children’s media.

It is unclear in previous literature whether anthropomorphic media helps or hinders children’s generalization of factual information to real animals. While Ganea and colleagues (2011, 2014) did not find that anthropomorphic language hindered learning, it also did not increase learning. However, the addition of anthropomorphic images in our study may negatively impact learning. Although children were able to learn factual information about the animals from storybooks in the previous research, they were less likely to do so when the books contained both anthropomorphic pictures and language (Ganea et al. 2014). However, the animals in this research were highly fantastical and humanized: wearing clothing, living in houses, eating at tables, and sleeping in beds. Walker, Ganea, & Gopnik (2012) found that children are less likely to generalize novel information embedded within a fantasy context to the real world than the same novel information embedded within a realistic context. Anthropomorphized animals that are placed within a more realistic context may not impede learning about animals due to their closer match to the real world referent (Mierek, 2010). However, even if we find that children are more likely to generalize factual information from our anthropomorphic storybooks to real animals, they may also be more likely extend psychological properties (Ganea et al. 2014) and use incorrect teleological or psychological language in their explanations of biological processes (Legare et al. 2013) than children exposed to factual storybooks. In order to explore these possibilities, in the current research, we measured the impact of anthropomorphic language and pictures on recall, generalizations, and explanations of the presented biological property of camouflage.
Importantly, the studies discussed above only examined children’s learning and transfer of specific biological facts from storybook content to real animals. We are also interested in whether the use of anthropomorphism in children’s media impacts children’s anthropocentrism. Are children more likely to see all animals as biological entities or as psychologically more similar to humans after being read a storybook about specific animals using an anthropomorphic framework? In addition to measuring recall and generalization of specific facts, we also measured anthropocentric reasoning about animals more generally by using a biological induction task, a biological and psychology property attribution task, and a scale for measuring anthropomorphic beliefs in children and adults. Prior research has found that when given a biological context, children are more willing to generalize biological properties to all animals regardless of the degree of behavioral similarity to humans (Gutheil et al., 1998). Additionally, one recent study suggests that priming 5-year-old children with an anthropomorphic children’s storybook produces the standard anthropocentric reasoning pattern whereas priming with a children’s animal encyclopedia leads children to adopt a biological pattern of reasoning (Waxman et al., 2014). However, again, this study used highly humanized animals, and it is unclear whether these characters are even recognized as animals or are contributing to children’s thinking about humans (Friedman, 2011; Parker & Lepper, 1992). In the current study, we may still find that the increased attention to human features in the anthropomorphic storybook may lead these children to treat the featured animal as human and show anthropocentric biological attribution patterns while also attributing more psychological properties to other animals than those in the control or factual conditions. On the other hand, a lesser degree of anthropocentrism may lead to less pronounced
differences between conditions than those found in previous research (Ganea et al. 2014, Waxman et al. 2014).

Finally, in Study 5, we aim to evaluate the contributions of both the style of the verbal narrative and the style of the illustrations in children’s learning from storybooks. In the current study, we presented children with one of four different books that systematically varied in their use of both anthropomorphic images and language, allowing us to independently evaluate the influence of anthropomorphic images and language on children’s biological and psychological knowledge of real animals. From previous research, it is unclear whether the pictures or words will have a greater impact on knowledge. Only one prior study systematically manipulated anthropomorphism in both language and pictures (Ganea et al. 2014). These researchers found that the combination of anthropomorphic pictures and language together decreased children’s transfer of factual information from storybook animals to real animals of the same species, but that either anthropomorphic language or pictures alone were sufficient to increase children’s attributions of psychological properties to real animals of the same species. It is still unknown how pictures and language independently contribute to children’s anthropocentric reasoning about animals more generally. Due to the salience of perceptual cues to young children (e.g., Brandone, Pence, Golinkoff & Hirsh-Pasek, 2007), we expect to find that anthropomorphic pictures will impact children’s performance on the post-test measures more than anthropomorphic language.

The results from the current study should shed more light on how the use of anthropomorphism in both pictures and language influences children’s biological knowledge about real animals. Specifically, does an anthropomorphic representation
influence the perceived biological and/or psychological similarity between animals and humans? Furthermore, does anthropomorphism impede generalization of biological information to real animals? Finally, what is the relative contribution of pictures and text to children’s learning?

**Method**

**Participants.** Sixty 4-year-olds (30 females, M = 4 yrs, 7 mo, range: 3 yrs, 11 mo – 5 yrs, 5 mo) participated in the current study and were randomly assigned to one of five conditions (four experimental conditions and one control condition) described below. Families were recruited through a participant database of interested parents as well as through local preschools. Parents were invited to participate via phone, email, or a letter sent home with their child. Participants lived in suburban communities within the New York/New Jersey metropolitan area. The sample included Caucasian (38.3%), Asian (13.3%), African American (5%), Hispanic (10%), and mixed race (18.3%) participants. An additional 15% of families declined to disclose ethnicity information. Most parents (86.8%) had attained a college degree or higher. Occupation data was missing for 15% of parents. Of those who responded, most parents held management, business and financial occupations (27.5%) or professional and related occupations (42.2%). 18.6% of parents reported being full-time stay at home parents. Participants took part in the study at either the Infant Cognition Center at Rutgers University, a quiet area of the child’s preschool, or in the family’s home. Parents gave written consent for their child’s participation. Parents were compensated with $20 and children were compensated with a small toy.
Procedure. Children in the four experimental groups (%N = 48, 24 females, M = 4 yrs, 7 mo, range: 3 yrs, 11 mo – 5 yrs, 5 mo) were read an age-appropriate storybook featuring animal characters (frog, butterfly, bird) and designed to teach children about camouflage (Figure 3). Children were randomly assigned to one of four different book styles: (1) realistic pictures with factual language, (2) realistic pictures with anthropomorphic language, (3) anthropomorphic pictures with factual language, and (4) anthropomorphic pictures with anthropomorphic language. In the realistic storybook condition, factual language introduced biological facts devoid of social or personifying information. Additionally, the storybook used realistic line drawings of photographs. Anthropomorphic storybooks, in contrast, introduced biological facts within an intentional framework, which referred to the intentions and desires of personified, named animals (e.g., Johnny the Bird) with anthropomorphic pictures showing animals in human-like postures and displaying human facial expressions. The two cross conditions allowed us to look at the relative impact of anthropomorphism in pictures and language.

The twelve 4-year-olds in the control condition (6 females, M = 4 yrs, 9 mo, range: 4 yrs, 2 mo – 5 yrs, 5 mo) were not exposed to any storybooks but participated only in the experimental tasks, allowing us to estimate children’s baseline levels of biological knowledge, anthropocentrism, and knowledge of camouflage.

Post-test Measures. After the book-reading session, children participated in two types of post-test assessments: those measuring children’s biological and psychological knowledge about animals and those measuring comprehension of camouflage. The animal knowledge tasks included the biological induction task, property attribution task,
and anthropomorphism questionnaire. Measures of comprehension and learning included a story recall and generalization task.

**Biological induction task.** Children completed a modified version of the biological induction task adapted from Tarlowski (2006) in which children are asked to project novel properties from base species on which the property is initially taught to other species that bear varying degrees of similarity to the base. Property projection thus provides a measure of perceived biological similarity between entities (Ross et al., 2003); participants extend the property to the target entities that they see as biologically similar to the base entity. The modified task was chosen because it is both brief and engaging, allowing us to include multiple trials with minimal attrition. The task had six trials, each with a presentation and test phase. In the presentation phase, children were shown a base species and introduced to a novel, internal biological property (i.e., people have “andro” inside). Children were presented with six bases: humans, the animals from the storybook (frog and butterfly), and animals not in the storybook (dogs, cows, fish). In the test phase, a display was revealed depicting the base species and the internal biological property, and a 3 x 3 array of target entities, including the six animals also used as bases (humans, dogs, cows, butterflies, frogs, fish), a plant (tree), and an artifact (car) (see Figure 4). Children were asked to point to the target entities they thought also possessed this novel property (“Which of these things do you think also have andro inside like people do?”). The bases were presented in a random order for each participant.

**Property attribution task.** Children also completed a property attribution task (Gutheil, Vera, & Keil, 1998; Inagaki & Sugiyama, 1988). In this task, children were shown an array of six targets: lion, crayon, ant, frog, human, and flower. After being
asked to name each picture to verify familiarity, children were asked to pick out the targets that had certain biological and psychological properties. For biological properties, children were asked which of the targets could eat, sleep, grow, and have blood inside. For biological properties, each correctly identified target (i.e., attribution of the property for animals, non-attribution of the property for non-living things) was scored as ‘1’ and a total score was calculated by summing all correct responses, resulting in a possible score between 0 and 24. For psychological properties, children were asked which of the targets could think, feel happy, sad, and scared. The number of times the child attributed a property to any non-human entity was summed, for a psychological attribution score between 0 and 20.

*Anthropomorphism Questionnaire.* Finally, a standardized measure of anthropomorphic beliefs was used to assess individual differences in anthropomorphism. The Individual Differences in Anthropomorphism Questionnaire - Child Form (IDAQ-CF) has been adapted from an adult measure (IDAQ) developed by Waytz et al. (2010) and validated for use with children as young as five years of age (Severson & Lemm, 2013). Although our sample is slightly younger than previous samples, preliminary testing revealed that children understood the measure and had no difficulty completing the task. In the task, children are asked whether and to what extent (a little bit, a medium amount, or a lot) non-human entities (technological objects such as computers, non-living natural entities such as mountains, and animals) possess a range of psychological abilities (e.g., intentions, emotions, consciousness, and mind). The 12 items are presented in random order. Based on previous research with both children and adults, two total
attribution scores were summed for each child: attributions to technology/nature and attributions to animals.

*Story recall and generalization.* To measure recall, the experimenter asked the child to “tell me what happened in the story.” General prompts such as, “Do you remember anything else?” and “What happened after that?” were used until the child reported everything that he or she remembered. Responses were recorded and later transcribed verbatim and coded for language use. Children’s recall was coded using a weighted scale that accounted for the number of facts recalled from the story (e.g., character details, physical properties related to camouflage, intentional motivations of the animals, etc.) as well as the relevance of the facts to the target property to be learned. Each fact was weighted with a score of 1 (irrelevant to camouflage such as the type or name of the animal) or 2 (fact relevant to camouflage such as colors or hiding for survival). Additionally, the language the child used to recall the narratives was coded as factual (e.g., “the frog was on the green leaf so the bird didn’t eat him”) or anthropomorphic (e.g., “Sammy tricked the bird”). Reliability for each coding scheme was determined separately by comparing the codes of a primary coder with those of a second independent coder blind to condition. The intra-class correlation coefficient was calculated to determine reliability for the factual recall coding (Shrout & Fleiss, 1979). Overall, agreement was very high, *ICC*(2,1) = .983. Using Cohen’s kappa as the agreement statistic, reliability for language coding was .60 (82.2%), indicating a good level of agreement (Fleiss, 1981). The primary coder reviewed any disagreements and selected a final code.
To test generalization of knowledge, we used the same post-test as Ganea et al. (2011). In their task, children received two within-category test animals (same animals that were featured in the book) and two-across category test animals (animals that were not featured in the book) to assess whether children extend knowledge about camouflage to real animals and how they justify their answers. For each animal, there were two trials: one with similar-looking animals (e.g., two green frogs, one on a green leaf one on a yellow flower) and one with different-looking animals (e.g., one green frog and red frog, both on green leaves). On each trial, children were presented with a real picture of the predator animal (the bird from the story) and told that he was still hungry and looking for something to eat. The child was then shown a pair of pictures of a camouflaged and a non-camouflaged animal and asked which one the predator animal would eat. After completing 8 trials, the experimenter randomly chose one of the trials on which the child correctly chose the non-camouflaged animal and asked the child why they said the bird would eat that one and why it wouldn’t eat the other one. As with story recall, the language the child used to explain his or her choice was coded as factual (e.g., “he’s not the same color as the flower”) or anthropomorphic (e.g., “the bird likes that one more”). Additionally, the sophistication of the explanation was coded on a scale of 0 (information not relevant to camouflage), 1 (mentioning only one aspect relevant to camouflage, such as the color of just the animal) or 2 (describing both elements relevant to camouflage—the color of the animal and the color of the background) or 3 (explicitly referencing camouflage). Reliability for each coding scheme was determined separately by comparing the codes of a primary coder with those of a second independent coder blind to condition. Using Cohen’s kappa as the agreement statistic, reliability factual coding
was .81 (83.3%) and for language coding was .80 (93.6%), both indicating a very good level of agreement (Fleiss, 1981). The primary coder reviewed any disagreements and selected a final code.

**Parent Surveys.** We also gathered self-report data from parents on their own beliefs about and sentiments towards animals. Parents completed the Animal Attitude Scale (Herzog, Betchart & Pittman, 1991). This scale assess attitudes towards animal welfare issues such as raising animals for human consumption, hunting for food or sport, and using animals in medical research. Items are scored and tallied with higher scores indicating more pro-animal welfare attitudes. Parents also completed the Belief in Animal Mind survey (Hills, 1995), which asks participants to what extent they believe different types of animals (mammals, birds, fish, insects) are capable of certain mental states, such as conscious awareness, feelings and emotions, problem solving, and mechanical responding to reflexes and instincts. Items are scored and tallied for each type of animal, with higher scores indicating a greater belief in animal mental abilities.

**Results**

**Children’s biological and psychological concepts about animals.** Our first set of analyses focused on whether anthropomorphism in both language and pictures influences perceived biological and/or psychological similarity between animals and humans. First, we asked whether anthropomorphism impacted children’s projection of both biological and psychological properties to animals. A repeated-measures ANOVA using property type (biological, psychological) as a within-subjects factor comparing the five conditions (four storybook conditions plus the control) and controlling for age revealed no effect of property type, condition, or interactions between the two, all \( p \)’s >
Overall, regardless of book experience, children scored very high on biological knowledge about animals ($M = 18.82, SD = 2.63$, on a scale of 0-24) while rarely attributing psychological properties to non-humans ($M = 8.12, SD = 4.63$ on a scale of 0-20).

Next, we investigated whether the type of storybook influenced individual differences in anthropomorphic beliefs about living and non-living entities as measured by the IDAQ-CF. A repeated-measures ANOVA using target type (living, non-living) as a within-subjects factor comparing the five conditions and controlling for age revealed no effect of target type, condition, or interactions between the two, all $p$’s > .24. Overall, regardless of book experience, children rarely attributed anthropomorphic qualities to either animals ($M = 4.25, SEM = .37$, on a scale of 0-16) or non-living entities ($M = 4.48, SEM = .71$ on a scale of 0-32).

Additionally, we found no effect of gender and no relationships between parents’ responses on either the Animal Attitude Scale of the Belief in Animal Mind and their children’s scores on the IDAQ-CF or property attribution tasks in any condition.

Finally, for the biological induction task, we tailored our analyses to focus on two projection patterns that have been taken as signatures of anthropocentric reasoning (e.g., Carey, 1985; Ross et al., 2003; Waxman et al., 2014): asymmetries in reasoning and generalization patterns to other animals. Preliminary analyses revealed no effect of gender or parents’ attitudes toward animals on any of the biological induction task results.

First, we looked for evidence of an asymmetry between projections from humans to dogs versus dogs to humans, with stronger projections in the former revealing
anthropocentric reasoning. A repeated-measures ANOVA using base (human, dog) as a within-subjects factor and condition as a between-subjects factor controlling for age found no significant effect of base, condition, or interaction between base and condition, all $p$’s > .56, suggesting that no groups showed an asymmetry in their projections. Separate repeated measures ANOVAs comparing anthropomorphic language conditions and anthropomorphic picture conditions found similar results to the overall ANOVA, all $p$’s > .25. Thus, anthropomorphic storybooks did not increase anthropocentrism. Across conditions, children were just as likely to project a novel property from a human to a dog as they were from a dog to a human, contrary to previous findings with this age group.

To look more broadly at asymmetries in reasoning, we compared children’s projections from dogs to animal targets and humans to animal targets across the three conditions. As in the previous analysis, favoring humans as an inductive base for novel biological properties by showing stronger projections from humans to animals than dogs to animals reveals anthropocentric reasoning. First, we looked at the impact of anthropomorphic language on anthropocentric projection patterns. A repeated-measures ANOVA using base (human, dog) as a within-subjects factor and condition (control, realistic language, anthropomorphic language) as a between-subjects factor controlling for age revealed no main effects or interactions, all $p$’s > .15. Next, we looked at the impact of anthropomorphic pictures on anthropocentric projection patterns. A repeated-measures ANOVA using base (human, dog) as a within-subjects factor and condition (control, realistic pictures, anthropomorphic pictures) as a between-subjects factor controlling for age revealed a marginal effect for book type, $F(2,55) = 3.085, p = .054, \eta_p^2 = .101$ (Figure 5). Bonferroni adjusted pairwise comparisons revealed that children
read a storybook with anthropomorphic pictures ($M = .81$, $SEM = .07$) were marginally more likely than those in the control group ($M = .53$, $SEM = .10$) to extend the novel property to animals, $p = .088$. There was no difference between either the control or the anthropomorphic groups and the realistic pictures groups ($M = .62$, $SEM = .07$), both $p$’s > .22. Additionally, there was no effect of base and no interaction between base and condition, both $p$’s > .41.

The same pattern was found when we considered whether anthropomorphic images or language influenced children’s likelihood of projecting a novel biological property to the animals featured in the book: bird, frogs, and butterflies. A repeated-measures ANOVA using base (human vs dog) as a within-subjects factor and book type (control, realistic images, anthropomorphic images) as a between-subjects factor controlling for age revealed a marginal effect for book type, $F(2,54) = 2.93$, $p = .062$, $\eta^2_p = .098$. Bonferroni adjusted pairwise comparisons revealed that children read a storybook with anthropomorphic images ($M = .81$, $SEM = .07$) were marginally more likely than those in the control group ($M = .52$, $SEM = .11$) to extend the novel property to the animals from the storybook, $p = .095$. There was no difference between either the control or the anthropomorphic groups and the realistic images groups ($M = .62$, $SEM = .07$), both $p$’s > .25.

**Children’s comprehension and learning about camouflage.** Next, we addressed whether anthropomorphic images and/or language influences children’s recall, generalization, and explanations about the specific biological property being taught to children in the books: camouflage. An ANOVA looking at differences in children’s recall score for the four different book conditions controlling for age found no effect of
condition, $p = .81$, suggesting that children recalled a similar number of camouflage facts from the storybooks regardless of anthropomorphic content. A chi-square analysis was used to test whether children differed in their use of anthropomorphic language in recalling the storybook across conditions, revealing a significant relationship between these variables, $\chi^2(3, N = 44) = 20.02, p < .001$ (Figure 6). Children who were read a factual storybook almost never spontaneously added anthropomorphic language (10%), while children read an anthropomorphic storybook almost always recalled the storybook using anthropomorphic language (81.8%), confirming that children were attentive to the content of the storybooks. To test whether anthropomorphic pictures or language were responsible for anthropomorphism in children’s recall, separate chi-square analyses were conducted for the language and picture conditions. The chi-square comparing anthropomorphic and realistic language conditions in children’s use of anthropomorphic language in recall was significant, $\chi^2(1, N = 44) = 13.56, p < .001, w = 0.56$, while the chi-square for anthropomorphic pictures was not significant, $p < .17$. Thus, children’s use of anthropomorphic language is driven specifically by the presence of anthropomorphic language in the storybooks. In fact, children read a storybook with anthropomorphic images but factual language never spontaneously used anthropomorphic language to describe the story. However, children did use anthropomorphic language to retell the story even in the absence of anthropomorphic images (33%).

Given that anthropomorphic language is reflected in children’s recall of the events, the next question is whether anthropomorphic information also influences their generalization of the biological property to novel animals. To measure this, we looked at children’s performance on the generalization task across conditions. An initial ANOVA
testing differences in generalization performance between conditions controlling for age
found no effect of condition, $p = .66$. However, further testing revealed a gender effect.
An ANOVA looking at differences in generalization performance as a function of
anthropomorphic language conditions (control, realistic language, anthropomorphic
language) and gender controlling for age found no effects, all $p$’s > .17. However, a 3
(picture condition: control, realistic, anthropomorphic) x 2 (gender) ANOVA comparing
differences in generalization and controlling for age revealed a significant interaction
between gender and condition, $F(2,59) = 3.40$, $p = .041$, $\eta_p^2 = .114$ (Figure 7). Separate
ANOVAs conducted for each gender revealed that for girls, the type of storybook
pictures had no effect on generalization, $p = .724$. For boys, in contrast, the type of
storybook pictures did affect generalization, $F(2,29) = 6.55$, $p = .005$, $\eta_p^2 = .335$.
Bonferroni adjusted pairwise comparisons reveal that boys read storybooks with
anthropomorphic pictures ($M = 6.48, SEM = .48$) performed significantly better on the
generalization task than boys in either the control group ($M = 4.24, SEM = .65$), $p = .031$,
or those read storybooks with factual pictures ($M = 4.33, SEM = .44$), $p = .008$.
Additionally, Bonferroni adjusted pairwise comparisons revealed that boys read
storybooks with anthropomorphic pictures perform significantly better than girls in either
the anthropomorphic ($M = 3.64, SEM = .58$), $p < .05$ or the factual storybook conditions
($M = 4.47, SEM = .66$), $p < .05$. Overall, it appears that girls were not learning from any
of the storybooks; generalization scores for girls were no different from chance across all
the conditions including the control group. The performance of boys in the control and
factual pictures conditions was similar to that of girls, hovering around chance. However,
boys who were read stories with anthropomorphic pictures performed significantly better on the generalization task, averaging 80% correct in this condition.

Finally, we asked whether anthropomorphism influences children’s understanding and explanation of camouflage. First, we examined whether anthropomorphic storybooks encourage children to explain camouflage anthropomorphically. A chi-square analysis comparing storybook conditions and use of anthropomorphic explanations was not significant, \( p = .50 \). Very few children (16.7%) used anthropomorphic explanations across any conditions. Next, we looked at whether anthropomorphic language and pictures affect children’s ability to understand and explain why a predator would eat a non-camouflaged animal. An ANOVA comparing language conditions and controlling for age revealed no effect of gender or condition, all \( p > .13 \). However, an ANOVA comparing picture conditions and controlling for age revealed a significant effect of condition, \( F(2,59) = 4.03, p = .023, \eta^2_p = .132 \) (Figure 8). Bonferroni adjusted pairwise comparisons revealed that children’s explanations contained higher level details after they were read a storybook with anthropomorphic pictures (\( M = 1.35, SEM = .22 \)) than children in the control group (\( M = .30, SEM = .32 \), \( p = .027 \). The level of detail recalled by children in the factual picture conditions (\( M = .80, SEM = .21 \)) did not differ from either the control or anthropomorphic conditions, both \( p’s > .24 \). Furthermore, there was no effect of gender, suggesting that both boys and girls provided more sophisticated explanations for their generalization choices after being read a storybook with anthropomorphic pictures.

Discussion
In Study 5, we experimentally examined the impact of anthropomorphic language and pictures on children’s biological and psychological concepts about animals. In line with previous research (Waxman et al. 2014), we expected to find that anthropomorphic media would increase anthropocentrism as measured by a biological induction task. However, we found instead that children who were read a storybook with anthropomorphic pictures were more likely to adopt a biological stance, projecting the novel property from one animal (either a human or a dog) to other animals, including the animals featured in the storybooks, at a higher rate than children who were not read a storybook. Surprisingly, no children in our sample showed the typical anthropocentric asymmetry commonly observed in this age group—favoring humans over dogs as inductive bases for novel biological information. Previous work has suggested that among urban children, 3-year-olds show biological reasoning patterns while 5-year olds show anthropocentric reasoning patterns (Herrmann et al., 2010), which may be why our sample of 4-year-olds showed little evidence of anthropocentrism, even in the control group; these children may still be in the process of acquiring the anthropocentric bias. Additionally, we found no differences in knowledge of specific biological properties of animals; this may be due to a ceiling effect, in that children averaged 80% correct. Also contrary to our predictions and previous work (Ganea et al. 2014), anthropomorphic media did not increase children’s psychological property attributions or anthropomorphic beliefs about animals.

Indeed, our findings are consistent with Inagaki & Hatano’s (1987, 2002) hypothesis that personification as analogy plays an important role in fostering the construction of a naïve biology. These researchers argue that humans serves as a
privileged source of information for children and that personification of animals helps children to analogically extend knowledge about their own behavior and biological functioning to less familiar animals. This also mirrors findings from our previous research on children who grow up with pets, which suggested that social experience with real animals decreases anthropocentrism (Geerdts et al., under review). Thus, for young children, social information about animals may facilitate their recognition of commonalities between animals and humans, enabling them to infer that animals and humans share many other biological properties.

These findings conflict, however, with other findings; recent work using commercial storybooks found that for 5-year-olds, realistic storybooks primed biological reasoning while anthropomorphic media primed anthropocentric reasoning (Waxman et al., 2014). These authors argue that 5-year-olds are able to reason flexibly, either biologically or anthropocentrically, about animals, and that media can prime one type of thinking or the other. However, our findings with 4-year-olds revealed a very different pattern, instead suggesting that anthropomorphism helps to promote biological reasoning rather than increasing anthropomorphic psychological reasoning. One potential explanation for this difference lies in the degree of similarity between humans and animals in the anthropomorphic storybooks conditions. Waxman et al. (2014) used a commercial *Berenstain Bears* book, which features bears as human stand-ins, showing them walking, talking, wearing clothing, and living in houses. Our storybooks showed animals in natural habitats only possessing human-like body postures and facial expressions. Thus, their study may have actually primed thinking about *humans*, which
increased anthropocentrism, whereas our study merely increased children’s connection with and attention to *animals*, leading to an increase in biological reasoning.

Our results also suggest that anthropomorphic images and pictures in children’s media do influence children’s learning of factual biological information. Children were sensitive to the type of language used, describing the characters anthropomorphically only after being read a storybook with anthropomorphic language. Interestingly, children did not spontaneously anthropomorphize in the factual language conditions, even when anthropomorphic images were used, suggesting that anthropomorphic character descriptions were influenced by the intentional and psychological language used in the storybook rather than being primed by anthropomorphic images. This highlights that the content of the storybooks is especially relevant to what children remember and potentially learn from storybooks. Thus, daily experiences with anthropomorphic media accumulated consistently over a long period of time may have a substantial effect on children’s biological reasoning. We also did not find that anthropomorphism impeded recall; children were able to recall just as many camouflage facts in the anthropomorphic and realistic conditions.

Importantly, we found partial evidence that our anthropomorphic media, especially pictures, increased learning. After being read a storybook with anthropomorphic pictures, boys were significantly more able than any other group, including girls in the same condition, to identify a non-camouflaged animal as being more likely to be eaten by a predator. Boys in this group averaged over 80% correct, while every other group performed no differently from chance. That this finding was limited to boys was surprising. We would have expected girls to be more attentive in both
conditions, since girls generally are rated as more attentive and eager to learn than boys, a factor that contributes to girls’ typically more robust academic performance (Cornwell, Mustard, & Van Parys, 2013). However, it may be that the anthropomorphic pictures and the topic of animal survival taken together were simply more engaging to boys than girls. Some previous research has found that young boys and girls differ in their reading preferences; for instance, boys are less likely to enjoy social reading and more likely to prefer comics, books about animals, and adventure books (Artola, Sastre, Gratacos, & Barraca, 2013). Thus, the topic and pictures may have captured their attention and as a result increased learning and generalization. However, further research will need to be conducted in order to determine whether this finding is representative of other types of properties and for other groups of children.

Additionally, both boys and girls were better able to explain why the predator would eat the non-camouflaged animal after being read a storybook with anthropomorphic images than children who weren’t read a storybook. Children read a storybook with factual images were no better at providing a camouflage explanation than the control group. This suggests that children in the anthropomorphic picture conditions were learning more about camouflage from our intervention than those in the factual condition. Again, contrary to our hypothesis and previous research (Legare et al. 2013), children read anthropomorphic stories were not more likely to use anthropomorphic reasoning to explain camouflage. This is especially interesting given that children read an anthropomorphic story were very likely to remember and use anthropomorphic language in recalling the story. Despite remembering facts about intentional motivations, children were able to learn and provide factual explanations about camouflage.
Importantly, our findings on children’s factual learning from storybooks build upon previous results from Ganea et al. (2011). These authors found that after being read a storybook about camouflage, children were better at able to explain camouflage and generalize to other animals regardless of the language used (intentional vs factual). Similarly, we found no influence of anthropomorphic language on generalization or explanation. However, our research also addressed the role of anthropomorphic illustrations on children’s learning, revealing that anthropomorphism does increase children’s learning, as evidenced by more sophisticated camouflage explanations. However, whereas they found that children’s generalization increased in both book conditions, we found this effect only for boys in the anthropomorphic picture conditions. Additionally, while Ganea et al. (2011) found that girls were generally more knowledgeable about camouflage at pre-test, we did not find any differences between boys and girls in the control group. In the previous study, the authors used a pre- and post-test assessment, which may have been more sensitive to knowledge changes than our use of a comparison control-group.

The current study clearly suggests that anthropomorphism may facilitate biological knowledge acquisition. However, our research was nonetheless limited in a number of ways. First, we focused on just one age group. Anthropomorphism may play a different role in learning at different ages. Other researchers have argued that young children are naturally anthropocentric (Carey, 1985; Kelemen, 1999) and thus anthropomorphic stories that match their reasoning framework are more easily comprehensible and memorable (Ganea et al., 2011). It is possible that as children get older and their reasoning becomes more biological, these anthropocentric stories are less
compatible with their reasoning and thus less beneficial for learning. Indeed, in Study 3 we found that 3-year-old children are more likely to prefer anthropomorphic stories than 5-year-old children. In the future, it will thus be important to extend this research to children of other ages.

Additionally, the books that we presented were still fairly realistic compared to commercial media. Our books features animals in natural habitats, whereas many published books use animals as human surrogates. As discussed above, it is possible that representations of animals as even more human-like than the current study may actually increase anthropocentrism, as they prime children to think about \textit{humans} and not animals (Ganea et al. 2014; Waxman et al., 2014). Coupled with that, the biological process that we focused on was one that is more relevant to animals than humans. Thus, future research should include other, more human-relevant properties (such as cross-species adoption or contagion) and more extremely personified animals in order to more clearly characterize the role and scope of anthropomorphism in biological reasoning and biological learning.

Finally, the current study represents only a tiny fraction of children’s daily experiences with animals and media. Although previous work in our lab suggests that daily social experiences with animals relates to increased conceptual and factual biological reasoning (Geerdts et al., under review a), it is unknown how daily anthropomorphic media relates to biological knowledge. Others have suggested that although anthropomorphism may initially relate to increases in memory learning, consistently embedding biological facts within an intentional framework may not facilitate biological causal reasoning (Ganea et al. 2011). However, longitudinal research
that investigates the impact of repeated exposure to factual and anthropomorphic media is necessary to better understand the consequences of daily media exposure for the development of biological and anthropocentric reasoning.

**General Discussion**

Anthropomorphism, the attribution of human characteristics to non-human entities, has long been a staple of human cognition. Some suggest that this widespread phenomenon may be a by-product of a system that is has been evolutionarily specialized to monitor and understand animate entities (Gazzola et al., 2007; New et al., 2007). Others suggest that humanization of non-human entities, though perhaps not arising through a specialized processing system, may nonetheless be useful in that it enables us to better understand, predict, and control our immediate environment (Guthrie, 1993). However, it can also lead to false predictions; we may expect non-human entities to behave like humans, which can result in dire consequences (Herzog, 2005; Strauss, 2006).

In the current set of studies, we examined the presence of anthropomorphic representations of animals in children’s media as well as its impact on children’s biological and psychological knowledge of real animals. In Study 1, we found that children’s television shows today are rife with anthropomorphism. In fact, in nearly all television shows where animals are present, the depictions are anthropomorphic. In Study 2, we found that even media with a biology-specific theme, such as storybooks about contagion, adoption, and camouflage, often feature anthropomorphic animals. Furthermore, these storybooks often lack accurate and biologically specific explanations, instead frequently embedding these stories in social and psychological contexts. Our
parent survey on children’s daily media use in Study 3 confirmed that the prevalence data from Studies 1 and 2 was representative of children’s actual media exposure; not only do anthropomorphic representations represent a high proportion of the media that is available to children, but media featuring these representations is precisely that which children prefer to watch.

In Study 4, we considered how parent-child interaction might shape children’s media use. Taken together with Study 2, our results suggest that neither the content of commercial storybooks nor the parent-child interactions that occur in the context of reading a storybook about adoption provide a ready source of sophisticated information about biologically causal mechanisms of inheritance, instead focusing on simple resemblance and shared activities. This study also investigated children’s knowledge of biological and psychological properties of animals. Although children knew about specific biological properties, they could not provide more detailed, biological explanations of how these properties function. Children often relied on psychological or intentional explanations related to human behavior in explaining biological phenomena, such as “when it’s the night that means they go to sleep like people” or “they get bigger…so they can be just like their mom and dad”. Children’s own knowledge, therefore, reflects the information provided in typical media experiences. We further explored this relationship empirically in Study 5.

Despite children’s media and interactions with parents being highly anthropomorphic as our first four studies showed, our results in Study 5 suggest that anthropomorphism may nonetheless support children’s learning about animals and their biological processes. Children read storybooks with anthropomorphic pictures showed
increased biological conceptual reasoning, attributing a novel biological property from animals and humans to animals more widely than children not read a storybook, and were also better able to explain why a predator animal would eat a non-camouflaged animal. Further, we did not find that anthropomorphism erroneously led children to incorrectly extend human-specific psychological properties to real animals.

Overall, the research presented here adds considerably to the limited body of research on the impact of anthropomorphic media on children’s knowledge about real animals. To date, both empirical findings and theoretical accounts of the role of anthropomorphic depictions of animals on children’s biological understanding have been mixed. Some previous experimental research suggests that anthropomorphism contributes to the development of anthropocentric reasoning (Waxman et al., 2014), leads to the incorrect extension of human specific psychological abilities (Ganea et al., 2014), and increases children’s recall and endorsement of anthropomorphic causal explanations (Legare et al., 2013). However, others argue that anthropocentrism may help children to better understand animals. By encouraging children to see social similarities between humans and animals, children are then in a position to analogically apply knowledge about their own biological functioning to less familiar animals (Inagaki & Hatano, 1987, 2002). The current research supports the latter hypothesis, demonstrating that anthropomorphic pictorial representations of animals increase children’s conceptual and factual biological reasoning. These images may help children see animals as more socially similar to humans, thus facilitating the inclusion of humans and animals in the same biological category.
Further research is needed to clarify the effect of different types of anthropomorphic representations on children’s knowledge about real animals. Our data were largely inconsistent with previous findings on anthropomorphic media exposure (Ganea et al., 2014; Legare et al., 2013; Waxman et al., 2014). All of these studies found a negative impact of anthropomorphism on anthropocentric reasoning and biological factual learning. However, an important difference between these studies and the current research was the pictorial depictions of animals. Two previous studies (Ganea et al., 2011; Legare et al., 2013) focused only on anthropomorphic language, for which we found no effect whatsoever on children’s reasoning or learning despite the fact that children clearly attended to the verbal style as reflected by differing amounts of anthropomorphism in their recall of the narratives. Other previous research (Ganea et al., 2014; Waxman et al., 2014) employed extremely personified animals that bore little resemblance to actual animals. Our work, in contrast, used anthropomorphic depictions of animals that still closely resembled their “animal selves” (Mierek, 2010). Our results suggest that storybooks with images of anthropomorphized “animal selves,” regardless of narrative style, increased biological conceptual reasoning and children’s ability to explain the biological property presented in the book. It is possible that more humanized depictions prevent children from identifying the characters as its animal species. Additionally, it is possible that children see more humanized animals as more fantastical, which may make the generalization of information to real animals more difficult. Previous research has found that even though children recall equal amounts of information from real and fantasy stories, they have significantly more trouble generalizing information from fantasy stories to reality (Richert & Smith, 2011). Further
research is needed which systematically varies the degree of anthropomorphism in order to determine whether the use of more humanized animal depictions would result in less learning and more anthropocentrism, reconciling differences in our findings from “animals selves” with previous research with more extremely humanized animals.

Our research suggests that children are highly interested in anthropomorphism; in Study 3 we found that many of children’s favorite shows feature anthropomorphic animals. These types of animals may be particularly engaging to children, simultaneously engaging their interest in fantasy and their interest in humans. Thus, it is possible that increased attention to these animals explains the increased learning of biological explanations that we observed in Study 5. We did find that factual recall did not differ across conditions, which would seem to argue that a lower-level mechanism such as attention was not the sole cause for this increase. However, because the current research did not directly measure children’s attention, this suggestion is speculative. An important goal for future research will be to empirically investigate whether attention serves as the mechanism for the observed increase in learning from anthropomorphic storybooks. Previous research measuring storybook attention has used eye-gaze analysis (e.g., Justice, Skibbe, Canning, & Lankford, 2005; Verhallen & Bus, 2011) and probed recall (e.g., Evans, Williamson, & Pursoo, 2008), which together may better reflect attention than the free recall task used in our current research.

The current research suggests that exposure to just one anthropomorphic storybook can affect children’s biological knowledge. As we observed in our own analyses of children’s television and storybooks, anthropomorphic animals are exceedingly common in children’s media. Parents also provide additional
anthropomorphic information during joint storybook reading. However, further research is needed to explore whether consistent exposure to anthropomorphic media over extended time periods results in greater effects on children’s biological knowledge about real animals. It is possible that children’s typical everyday exposure to anthropomorphic media may not result in the same effects on children’s learning about animals as found in the current work, because of differences in the type of anthropomorphism as discussed above. Additionally, other researchers have suggested that while limited exposure to anthropomorphic media may not interfere with learning, consistently embedding biological facts within an intentional framework may not facilitate biological causal reasoning (Ganea et al. 2011). A possible area of future research to study the effects of repeated exposure would be to have parents read their children multiple books like the one created in the current work repeatedly over the course of a month and measure children’s learning. We may find that repeated exposure to the less extreme anthropomorphism used in our stimuli in Study 5 result is even stronger effects in the direction observed in the current research, while repeated exposure to more humanized animals, as is typical of much of children’s media, results in stronger effects of the type seen in previous research (Ganea et al., 2014; Waxman et al., 2014).

Additionally, the current experimental research was limited to the effects of one form of media: storybooks. Exploring the effects of other types of media on children’s biological knowledge is essential. We found in Study 2 that television programs geared towards preschool-aged children are often created with educational goals. Furthermore, these educational programs are just as likely as general audience programs to use anthropomorphism. An important goal of future research will be to empirically study the
effect of television viewing on children’s animal concepts and biological learning to determine whether the result is the same as from storybook reading. Prior research has found a *video deficit effect* (Anderson & Pempek, 2005); children under 3 years of age are less likely to learn from screen media than from a live person. Thus, we may find that among this age group television shows have less of an impact than storybook reading on children’s conceptual and factual knowledge. Additionally, newer forms of screen media, such as digital applications (‘apps’) for iPhones and iPads, are increasingly common but surprisingly understudied. Out of the 200 top selling apps in the iTunes Education category of apps, 58% are geared towards toddlers and preschoolers (Shuler, 2012) and more than a quarter of parents have downloaded apps for their young children (Common Sense Media, 2011). Furthermore, four out of five of the top educational apps focus on STEM subjects, making these a relevant and common experience for the development of children’s early science experiences. However, the educational value and effectiveness for learning of these apps is very unclear; only 14% of the top-selling educational apps have been evaluated by one of the leading children’s software assessment organizations, the Children’s Technology Review (Shuler, 2012). Whether the video deficit effect also extends to newer interactive screen media like apps, and how these apps contribute to early biological learning, is an important area for future research as well.

This work has important implications for the creation of scientific educational media. As a result of a renewed interest in improving preschool education and boosting scientific literacy, early science learning has become a major focus of many leading educational and research groups, including the National Association for the Education of Young Children, National Science Foundation, and the US Department of Health and
Human Services. Science-based programs for preschool audiences have received major investments from science industry leaders, reflecting the belief that early exposure to scientific concepts forms the foundation for later learning (Brenneman, 2011). Our results suggest that anthropomorphistic media may indeed more readily engage children’s attention and/or connection to animals and as a result leads to increases in factual learning about biological properties. Thus, educational science media may actually benefit from the use of anthropomorphistic images. While further research is still needed to validate and extend these findings to other media formats, levels of anthropomorphism, and additional biological properties before any strong conclusions can be drawn, our research does highlight the continued need for researchers and creators of educational media to consider how animal representations in children’s educational media can support or hinder children’s early biological learning.

In summary, while much research has focused on the content and development of young children’s biological concepts, little research has focused on the everyday experiences that may contribute to children’s knowledge development. The aim of the current research was to systematically examine a subset of these experiences to better understand the impact of cultural influences such as media and parental discourse on children’s biological concepts. Since anthropomorphistic media is highly prevalent in nearly all children’s homes, it is critical that more research focuses on the kinds of information children transfer from these media representations of animals to their real world counterparts. Future work should continue to aim to combine these foci, characterizing actual experiences and experimentally measuring learning outcomes, to
fully understand how direct and indirect daily experiences with animals can better support early biological knowledge development.
References


Geerdts, M. & LoBue, V. (under review). Educational child-directed media: Linking parental beliefs about educational media to actual media behaviors.


Table 1

Number of storybooks (and percent) with anthropomorphic language and/or pictures in Study 2

<table>
<thead>
<tr>
<th>Pictures:</th>
<th>Language: Realistic</th>
<th>Realistic</th>
<th>Anthropomorphic</th>
<th>Anthropomorphic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption Books</td>
<td>0</td>
<td>6 (30%)</td>
<td>0</td>
<td>14 (70%)</td>
</tr>
<tr>
<td>Illness Books</td>
<td>0</td>
<td>1 (4%)</td>
<td>0</td>
<td>24 (96%)</td>
</tr>
<tr>
<td>Camouflage Books</td>
<td>31 (77.5%)</td>
<td>9 (22.5%)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 2

Mean number of utterances per parent and percent of parents who provided at least one coded statement

<table>
<thead>
<tr>
<th>Inheritance</th>
<th>Adopted Family Resemblance</th>
<th>Biological Family Resemblance</th>
<th>Generic Category Reference</th>
<th>Shared Social Activities (Adopted)</th>
<th>Shared Social Activities (Biological)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical</td>
<td>0 (0%)</td>
<td>1 (75%)</td>
<td>1.5 (62.5%)</td>
<td>0.25 (25%)</td>
<td>-</td>
</tr>
<tr>
<td>Non-Physical</td>
<td>0 (0%)</td>
<td>1.13 (37.5%)</td>
<td>0.38 (25%)</td>
<td>5.38 (75%)</td>
<td>4.25 (100%)</td>
</tr>
</tbody>
</table>
Figure Captions

*Figure 1.* The distribution of television shows falling into each of the three coding categories: educational, format, and subject.

*Figure 2.* The percentage and number of younger and older children’s favorite screen media and books that feature anthropomorphic animals.

*Figure 3:* Examples of drawings and scripts from the factual and anthropomorphic camouflage storybooks in Study 5.

*Figure 4:* Sample trial of our modified biological induction task based on Tarlowski (2006) featuring base (top left), biological property (bottom left), and 3x3 array of targets.

*Figure 5:* Percentage of children in each of the three storybook picture conditions (control, realistic, anthropomorphic) who attributed the novel biological property from humans to animals and from dogs to animals.

*Figure 6:* Percentage of children who used anthropomorphic language when recalling the story within each of the four storybook conditions.

*Figure 7:* Mean number of correct generalization predictions by boys and girls in each of the three storybook picture conditions (control, realistic, anthropomorphic). Error bars represent SEM.

*Figure 8:* Mean explanation score of children in each of the three storybook picture conditions (control, realistic, anthropomorphic). Error bars represent SEM.
Figure 1
Figure 2

<table>
<thead>
<tr>
<th>Type of Media</th>
<th>Younger Children</th>
<th>Older Children</th>
<th>Younger Children</th>
<th>Older Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen Media</td>
<td>51</td>
<td>144</td>
<td>97</td>
<td>130</td>
</tr>
<tr>
<td>Books</td>
<td>35</td>
<td>83</td>
<td>47</td>
<td>80</td>
</tr>
</tbody>
</table>

- % of children's favorite media
- No Anthropomorphic Animals
- Anthropomorphic Animals

- 0% - 100%
“Some animals, like frogs and butterflies, can use camouflage to avoid other animals, like birds, who eat them.”

“Some animals, like Sammy the frog and Lucy the butterfly, like to use camouflage because they want to hide from naughty animals, like Johnny the bird, who try to eat them.”
Figure 4
Figure 5

% Children who attributed the property

Control  | Realistic Pictures  | Anthro Pictures

Storybook Condition

Humans to Animals  | Dogs to Animals
Figure 6

![Bar chart showing the percentage of children who used anthropomorphic language at recall. The chart compares factual and anthropomorphic pictures.](chart.png)
Figure 7

The bar chart shows the mean correct generalization predictions for different storybook types: Control, Factual Pictures, and Anthro Pictures. The chart compares boys and girls. The y-axis represents the mean correct generalization predictions, ranging from 0 to 8. The x-axis represents the storybook types.
Figure 8

The chart shows the mean explanation score for different storybook types: Control, Factual Pictures, and Anthro Pictures. The y-axis represents the mean explanation score ranging from 0 to 1.8, and the x-axis represents the storybook types. The chart indicates that Anthro Pictures have the highest mean explanation score, followed by Factual Pictures, and then Control.
Appendix A
List of Selected Television Shows Analyzed in Study 1

<table>
<thead>
<tr>
<th>TV Channel</th>
<th>Name of Television Show</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBS Kids</td>
<td>Angelina Ballerina</td>
</tr>
<tr>
<td></td>
<td>Arthur</td>
</tr>
<tr>
<td></td>
<td>Barney and Friends</td>
</tr>
<tr>
<td></td>
<td>Bernstein Bears</td>
</tr>
<tr>
<td></td>
<td>Betsy's Kindergarten Adventures</td>
</tr>
<tr>
<td></td>
<td>Between the Lions</td>
</tr>
<tr>
<td></td>
<td>Boohbah</td>
</tr>
<tr>
<td></td>
<td>Caillou</td>
</tr>
<tr>
<td></td>
<td>Clifford the Big Red Dog</td>
</tr>
<tr>
<td></td>
<td>Curious George</td>
</tr>
<tr>
<td></td>
<td>Dinosaur Train</td>
</tr>
<tr>
<td></td>
<td>Franny's Feet</td>
</tr>
<tr>
<td></td>
<td>George Shrinks</td>
</tr>
<tr>
<td></td>
<td>Jay Jay the Jet Plane</td>
</tr>
<tr>
<td></td>
<td>Lomax, the Hound of Music</td>
</tr>
<tr>
<td></td>
<td>Mama Mirabelle's Home Movies</td>
</tr>
<tr>
<td></td>
<td>Martha Speaks</td>
</tr>
<tr>
<td></td>
<td>Mister Rogers' Neighborhood</td>
</tr>
<tr>
<td></td>
<td>Make Way for Noddy</td>
</tr>
<tr>
<td></td>
<td>Postcards From Buster</td>
</tr>
<tr>
<td></td>
<td>Sagwa</td>
</tr>
<tr>
<td></td>
<td>Sesame Street</td>
</tr>
<tr>
<td></td>
<td>Sid the Science Kid</td>
</tr>
<tr>
<td></td>
<td>SUPER WHY!</td>
</tr>
<tr>
<td></td>
<td>Teletubbies</td>
</tr>
<tr>
<td></td>
<td>Toopy and Binoo</td>
</tr>
<tr>
<td></td>
<td>WordWorld</td>
</tr>
<tr>
<td></td>
<td>Zoboomafoo</td>
</tr>
<tr>
<td>Disney Jr.</td>
<td>Mickey Mouse Clubhouse</td>
</tr>
<tr>
<td></td>
<td>Jake and the Never Land Pirates</td>
</tr>
<tr>
<td></td>
<td>Handy Manny</td>
</tr>
<tr>
<td></td>
<td>Special Agent Oso</td>
</tr>
<tr>
<td></td>
<td>Imagination movers</td>
</tr>
<tr>
<td></td>
<td>Jungle Junction</td>
</tr>
<tr>
<td></td>
<td>Babar and the adventures of Babou</td>
</tr>
<tr>
<td></td>
<td>Little Einsteins</td>
</tr>
<tr>
<td></td>
<td>Chuggington</td>
</tr>
<tr>
<td></td>
<td>Tinga Tinga Tales</td>
</tr>
<tr>
<td></td>
<td>Charlie and Lola</td>
</tr>
<tr>
<td></td>
<td>Timmy Time</td>
</tr>
<tr>
<td>Nick Jr.</td>
<td>Dora The Explorer</td>
</tr>
<tr>
<td></td>
<td>Bubble Guppies</td>
</tr>
</tbody>
</table>
Dino Dan
Team Umizoomi
Yo Gabba Gabba!
Max & Ruby
The Fresh Beat Band
Go, Diego, Go
Ni Hao, Kai-lan
The Backyardigans
Wonder Pets
Toot & puddle
Wow wow wubbzy
Olivia
Jack's big musical show
Blue's Clues
Miss Spider
The Upside Show
Franklin
Little Bear
Oswald
Little Bill
Qubo
Pearlie Is In The Park
Animal Exploration with Jarod Miller
My Friend Rabbit
The Magic School Bus
The Mysteries of Alfred Hedgehog
Turbo Dogs
Willa
Jane and the Dragon
Rescue Heros
Babar
Jacob Two-two
Shelldon
The Zula Patrol
Appendix B
List of Selected Children’s Book Titles Analyzed in Study 2

**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 Joosse 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 Brandenberg and Aliki
- 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 Sneeze! 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

Camouflage Storybooks
Animal Camouflage in the Desert by Martha Rustad
Animal Camouflage in the Forest by Martha Rustad
Animal Camouflage in the Ocean by Martha Rustad
Animal Camouflage in the Snow by Martha Rustad
Animal Colors: A Rainbow of Colors from Animals Around the World by Beth Fielding
Animals in Camouflage by Phyllis Limbacher Tildes
Animals in Disguise: Amphibians by Lynn Stone
Animals in Disguise: Invertebrates by Lynn Stone
Camouflage and Disguise by Jason Cooper
Camouflage Clues: A Photo Riddle Book by Megan Cooley Peterson
Camouflage for Hiding by Ted O'Hare
Clever Chameleon by Alison Lodge
Coral Reef Survival by Eric Ethan
Disappearing Acts: Emerald Boas: Rain Forest Undercover by Catherine Nichols
Disappearing Acts: Green Tree Frogs: Colorful Hiders by Natalie Lunis
Disappearing Acts: Katydid: Leaf Look-Alikes by Natalie Lunis
Discover Science Animal Disguises by Belinda Weber
DK Readers: Animal Hide and Seek by Penny Smith
Hidden Animals by Valerie Guidoux
Extreme Readers: Undercover Creatures by Katherine Kenah
Hard-to-see Animals by Allan Fowler
Hidden Pictures by Nicki Palin
Hiding in a Coral Reef by Patricia Whitehouse
Hiding in a Desert by Patricia Whitehouse
Hiding In a Forest by Patricia Whitehouse
Hiding In a Rain Forest by Patricia Whitehouse
Hiding in the Ocean by Patricia Whitehouse
Hiding in the Woods: A Nature Trail Book by Maurice Pledger
How to Hide a Butterfly and Other Insects by Ruth Heller
How to Hide a Meadow Frog and Other Amphibians by Ruth Heller
How to Hide an Octopus and Other Sea Creatures by Ruth Heller
Hungry Little Hare by Howard Goldsmith
I See Animals Hiding by Jim Arnosky
Lots of Spots by Lois Ehlert
Octavia and her Purple Ink Cloud by Donna Rathmell German
Predators: Reptiles by Lynn Stone
Questions and Answers about Animal Camouflage by Anita Ganeri
Shark Camouflage and Armor by Victor Gentle
Stripes, Spots, or Diamonds: A Book about Animal Patterns by Patricia Stockland
Summer Coat, Winter Coat by Doe Boyle
Twilight Hunt: A Seek-and-find Book by Narelle Oliver
What Color is Camouflage by Carolyn Otto
Where in the Wild? By David Schwartz
Whose Spots are these? A Look at Animal Markings by Sarah Wahlrabe
Appendix C
Sample pages from the wordless storybook stimuli used in Study 4

Chester Finds a Family

We will take good care of Chester!

Finally....!
Appendix D
Full list of questions used in the post-test assessment in Study 4

Biological Properties
Do monkeys sleep? When do monkeys sleep (during the day or at night)? Why do they sleep?
Do you know what kinds of things are inside a monkey’s body? (Do they have blood? Do they have bones?)
Do monkeys breathe?
Do monkeys grow as they get older? Why? What makes monkeys grow?
What do monkeys eat? Why do monkeys eat?
What would happen if a monkey ate “people” food?
What would happen if a monkey ate too much food?
What would happen if a monkey didn't eat at all (for a long time)?
Do monkeys get sick?
If a monkey was sick and you played with the monkey, would you get sick too? Why?
If you were sick and you played with a monkey, would the monkey get sick too? Why?
What type of animal do you think monkeys’ parents are?
If a monkey had a baby, what type of animal would they be?

Psychological/Social Properties
Can monkeys talk to each other? What does it sound like when monkeys talk?
Can you understand them when they talk to each other?
Can you talk to a monkey (can they understand you)?
Do monkeys have friends? What type of animal?
Do monkeys ever feel happy? What kinds of things make them feel happy? How can you tell when a monkey is happy (what do they do)?
Do monkeys ever feel sad? What kinds of things make them feel sad? Do monkeys cry?
Do monkeys ever feel angry? What kinds of things make them feel angry? How can you tell when a monkey is angry (what do they do)?
CURRICULUM VITAE

DATE AND PLACE OF BIRTH

May 11, 1987
New York City, NY USA

EDUCATION

2005-2009 B.A. in Developmental Psychology
Magna Cum Laude and Departmental Honors
The College of New Jersey

2009-2012 M.A. in Cognitive Psychology
(Advisor: Dr. Gretchen Van de Walle)
Rutgers University- Newark

2012-2014 Ph.D. in Developmental Psychology
Child Research Labs (Co-Advisors: Dr. Gretchen Van de Walle
and Dr. Vanessa LoBue)
Rutgers University- Newark

RESEARCH AND TEACHING EXPERIENCE

Instructor, Rutgers University, Newark, NJ, Summer 2012, Winter 2013, Spring 2013,
Summer 2013.
Teaching Assistant, Rutgers University, Newark, NJ, Fall 2010, Spring 2011, Fall 2011,
Spring 2012, Fall 2012.
Research Assistant and Data Collector, National Institute for Early Education Research
(NIEER), New Brunswick, NJ, 2009-2010.

PUBLICATIONS

Manuscripts in revision
Geerds, M. & LoBue, V. (in revision). Educational child-directed media: Linking
parental beliefs about educational media to actual media behaviors

Manuscripts under review
Geerds, M., Van de Walle, G. A., & LoBue, V. (under review). Anthropomorphism and
biological explanations in children’s storybooks
Geerds, M., Van de Walle, G. A., & LoBue, V. (under review). Daily animal exposure
and children’s biological concepts.
in novel object categorization.
about biological entities in informal learning environments.