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Young Children's Learning and Transfer of Biological Information From Picture Books to Real Animals

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Preschool children (N = 104) read a book that described and illustrated color camouflage in animals (frogs and lizards). Children were then asked to indicate and explain which of 2 novel animals would be more likely to fall prey to a predatory bird. In Experiment 1, 3- and 4-year-olds were tested with pictures depicting animals in camouflage and noncamouflage settings; in Experiment 2, 4-year-olds were tested with real animals. The results show that by 4 years of age, children can learn new biological facts from a picture book. Of particular importance, transfer from books to real animals was found. These findings point to the importance that early book exposure can play in framing and increasing children's knowledge about the world.

Recent research has emphasized the important role of direct experience in children's acquisition of biological concepts (Hatano & Inagaki, 1994, 1999, 2002; Tarlowski, 2006; Waxman & Medin, 2007). Children growing up in different cultural settings (e.g., rural vs. urban) have different opportunities for informal learning about animals. In urban settings, a substantial proportion of young children's exposure to animals is indirect, through symbolic media such as television, videos, and books, with their direct exposure limited to household pets or visits to the zoo (Inagaki, 1990; Rosengren, Gelman, Kalish, & McCormick, 1991). Little is known about how children's indirect learning about biology through symbolic media influences their knowledge about real animals.

Until recently, almost no research had explored whether young children generalize information gleaned from factual picture-book interactions to the real world (see Fletcher & Reese, 2005 for a review). The majority of research on picture-book reading with young children has focused on two topics: the nature of the parent–child book-centered interaction and the effects of joint picture-book reading on emergent literacy and oral and written-skills (Adams, 1990; Bialystok, 1995; DeBaryshe, 1993; Justice & Ezell, 2000; Mason, 1980; Sénéchal & Cornell, 1993; Sénéchal & LeFevre, 2001; Sulzby, 1985; Teale & Sulzby, 1986; Whitehurst & Lonigan, 1998; Whitehurst et al., 1994).

One primary purpose of exposing young children to simple educationally relevant books is generalization of knowledge from the printed page to the real world. However, the extent to which young children do, in fact, acquire new information from picture-book interactions has not been systematically explored, possibly because of a general assumption that the answer is clear (e.g., van Kleeck, 2003). Yet young children do have difficulty in learning from symbolic media, with studies showing, for instance, better learning from direct experience compared to video (e.g., Anderson & Pempek, 2005; Barr & Hayne, 1999; DeLoache & Chiong, 2009; Hayne, Herbert, & Simcock, 2003; McGuigan, Whiten, Flynn, & Horner, 2007; Strouse & Troseth, 2008). Nevertheless, recent research suggests that when visual media socially engage children, learning is promoted (Troseth, Saylor, & Archer, 2006).

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Picture-book interaction is fundamentally a social activity (Ninio & Bruner, 1978), which may facilitate young children's learning. Pictures in storybooks can promote understanding of content by providing concrete illustrations of the ideas presented in the text. As they are being read to, preschoolers and kindergarteners primarily focus their attention on those details of the pictures that illustrate the meaning of the text (Evans & Saint-Aubin, 2005). Thus, pictures can facilitate comprehension of the content of a book by drawing attention to critical elements in the story and activating relevant knowledge (Newton, 1995).

Children's success at transfer from picture books depends, at a minimum, on their understanding of the referential nature of pictures—the fact that pictures can represent objects and situations in the real world (DeLoache & Burns, 1994). This ability is present by the time children reach their second birthday (Ganea, Allen, Butler, Carey, & DeLoache, 2009; Preissler & Bloom, 2007; Preissler & Carey, 2004). For instance, Preissler and Carey (2004) tested whether toddlers who were taught a new word in relation to a picture would apply that word to the depicted object itself or to its real-world referent. In their study, 18- and 24-month-old children were taught an unfamiliar label (''whisk'') for a small line drawing of an unfamiliar object (a whisk). Subsequently, they were presented with a pair of stimuli—a real whisk and the same simple drawing for which they had learned the label—and asked to ''show me a whisk.'' Of the fifty 18- and 24-month-olds tested, *only one* selected the picture alone, in spite of the fact that they had initially learned the label for the line drawing. All the children chose the real whisk, with half selecting the object alone and half the real object *and* its picture. Thus, by 18 months of age, toddlers who hear a novel word applied to a picture assume that the word also refers to the real object that the picture depicts. Another recent study suggests that toddlers' ability to take a real object as the referent of a picture can depend on the degree of perceptual similarity between the depiction and the real object (Ganea et al., 2009).

Only recently have researchers begun to focus specifically on the extent to which young children learn new content from picture books and the factors that affect their ability to generalize the information to the real world (Ganea, Pickard, & DeLoache, 2008; Ganea et al., 2009; Simcock & DeLoache, 2006, 2008; Simcock & Dooley, 2007). Although young children are capable of learning simple information (e.g., novel names or action sequences) from picture books, they have difficulty generalizing that information to novel stimuli or situations. In these studies, 15- to 30-month-old children were tested with real objects that either looked identical to the objects depicted in a book or with objects that differed in color from the depictions. Changing the appearance of the test stimuli interfered with children's generalization of the novel information from the picture book to the real objects.

In one of these studies, Ganea et al. (2008) showed that after a book-reading interaction in which 15- to 24-month-olds learned the label ''blicket'' for a depiction of a novel object, they identified which of two real objects was a ''blicket.'' Overall, children were more likely to transfer a label from a depicted to a real object with highly realistic pictures than with less realistic depictions (e.g., drawings and cartoons). This difference was especially pronounced for generalization to a novel exemplar of the depicted object. Thus, the nature of the pictures in books for very young children affects the extent to which they apply the information from the book to the real world (see also Simcock & DeLoache, 2006).

In addition to the important role of iconicity on children's transfer from pictures to real world objects, Simcock and Dooley (2007) have shown contextual effects on toddlers' extension of information acquired from a book. Toddlers generalized less to novel exemplars of the depicted objects when they were tested in a different room than the one in which they were exposed to the book. Similar problems are revealed by studies of older children's ability to interpret information depicted in pictures. For example, even 4-year-olds can show confusion about the properties of pictures and depicted objects (Beilin & Pearlman, 1991; Robinson, Nye, & Thomas, 1994) and the consequences of actions performed on them (Flavell, Flavell, Green, & Korfmacher, 1990). Young children can also have difficulty extracting action information from static pictorial depictions (Kose, Beilin, & O'Connor, 1983). Moreover, even at 6 years of age, some children maintain a belief in the ''fidelity of photographs,'' judging a photo that depicts an illogical outcome of an event to be a true depiction of reality (O'Connor, Beilin, & Kose, 1981). In sum, although children begin to appreciate the basic relation between pictures and their referents as early as 15 months (Ganea et al., 2009), their ability to use pictures symbolically develops throughout early childhood (Callaghan, 2000; DeLoache & Burns, 1994; DeLoache & Ganea, 2009; Ganea et al., 2009; Harris, Kavanaugh, & Dowson, 1997), and transfer

of information from pictures to reality can be tenuous.

The current research explores the extent to which preschool children can learn and transfer biological facts from picture books to real animals. Furthermore, we asked to what extent their transfer of information from picture books is affected by changes in the contexts at learning and testing, as it is for younger children (Hanna & Meltzoff, 1993; Hayne, Boniface, & Barr, 2000; Learmonth, Lamberth, & Rovee-Collier, 2004; Simcock & Dooley, 2007).

Another goal of the current research was to examine the effect of different frameworks for presenting biological information in books to children. In many books that are intended to teach children about the real world animals are anthropomorphized: They have names, and their behavior is described in intentional terms. Even 10th-grade students find these forms of presentation confusing (Tamir & Zohar, 1991). Anthropomorphism might be especially deleterious to young children's learning and generalization of biological facts from books to real animals for at least two reasons. First, it is character based and hence specific to an individual and its particular motivations. Second, it couches the animal's motivations in intentional terms. Thus, an anthropomorphic framework might lead children to think of the depicted animals as specific individuals with purposes and intentions, thereby interfering with generalization to real animals.

Alternatively, the use of an anthropomorphic framework to introduce biological facts to children might be helpful, because young children's reasoning about animals already has an anthropocentric basis. For example, when explaining the behavior of animals, preschoolers tend to attribute human abilities, purpose, and intentions to them (Carey, 1985; Kelemen, 1999; Kelemen, Widdowson, Posner, & Brown, 2003; Springer & Keil, 1989). This predisposition to view nonhuman acts as intentional persists into adulthood (Casler & Kelemen, 2008; Kelemen & Rosset, 2009; Lombrozo, Kelemen, & Zaitchik, 2007). It is not known whether the use of anthropomorphic elements in books designed to convey factual information about the world would make it more or less likely that children would appropriately generalize the facts to the real world.

To examine the effect of anthropomorphism on young children's learning of biological information, we presented preschool children with stories about color camouflage in either factual or intentional frameworks. The factual story presented straightforward fact-based explanations, whereas the intentional story presented the explanations in an anthropomorphic framework; that is, the animals were personified and described in terms of their desires and intentions. The question was whether the use of anthropomorphism would affect children's learning and transfer of the concept of color camouflage to pictures of animals and to live animals.

Experiment 1

Children were first exposed to a book that described why a predatory bird would be more likely to prey upon an animal in a noncamouflaged setting than an animal in a camouflaged setting. Picture–book interactions with young children involve both pictures and language and this study attempted to recreate the normal context of an adult reading a book to a child. The information in the book was conveyed in either factual or anthropomorphic language (see Appendix A). Children's learning and extension of the concept was tested with pictures of animals that belonged to either the same category as the animals depicted in the book (within-category items) or a different category (across-category items).

Method

Participants

The final sample included forty 3-year-olds (M = 42.0 months, range = 36.7–47.8 months) and thirty-two 4-year-olds (M = 52.9 months, range = 48.0–58.5 months), with equal numbers of males and females at each age. Seven additional children were excluded due to difficulty understanding the test questions (2), prior knowledge of camouflage as determined at pretest (4), or experimenter error (1). Children were recruited from a participant pool at a public university, and parents were contacted by telephone. The majority of children came from White, middle-class families. Equal numbers of boys and girls in each age group were randomly assigned to two book conditions.

Materials

Pretest stimuli. Two pairs of realistic photographs were used during the pretest, each pair illustrating biological camouflage in either caterpillars or lizards. In each pair, one animal was the same color as the background and thus difficult to detect; the color of the other animal was quite different from and highly visible against the

background. A picture of a predatory bird—a hawk—was also used.

Picture books. Two picture books (20 cm × 23 cm) with the same set of realistic photographs were used for the book-reading session. The information provided was in either factual or intentional language. The *factual story* used neutral, factual language to explain why a predator bird could or could not find a frog, depending on whether or not the frog was visible against the background. In the *intentional story,* the same explanation was embedded in an intentional framework, with the story referring to the intentions and desires of the animals who were personified with names (see Appendix A).

Test stimuli. Four new pairs of color photographs served as test stimuli. For each pair of pictures, one animal was camouflaged, and the other was not. Two pairs were within-category depictions—animals that belonged to the same category as the target animal in the book (frogs). The other two pairs were across-category depictions—animals from a different category than the animal depicted in the book (butterflies). For each group of pictures (within- or across-category), one pair of pictures showed two similar-looking animals in the same color (e.g., green tree frogs), and the other pair showed two different-looking animals in different colors (e.g., brown grass frog and orange tree frog). A picture of the bird from the book was also used.

Procedure

Pretest. A pretest with two trials assessed the child's prior knowledge of color camouflage. The experimenter and the child sat across from each other on the floor or at a small table. On each trial, the experimenter first placed a picture of a large predatory bird (a hawk) in front of the child, ''This is a bird that eats caterpillars. It's very hungry and is looking for something to eat.'' Then the experimenter placed a pair of pictures depicting a camouflaged and a noncamouflaged caterpillar below the image of the bird and asked, ''Which caterpillar will the bird eat, this one or this one (pointing)?'' The side on which the two pictures appeared was switched from the first to the second trial, and the experimenter always pointed to the picture on her right first. On each trial, the experimenter asked the child to justify his or her choice, ''Why will the bird eat this one?'' Only neutral feedback (e.g., ''Thank you'') was provided. The second trial was the same, except that pictures of lizards were used instead of caterpillars.

Book reading. Immediately after the pretest, the experimenter read the book to the child. Half of the children listened to the factual story and half heard the intentional story.

Posttest. After the book-reading session, a posttest with four trials was conducted to assess children's learning and generalization of color camouflage from the picture book. The posttest took place in the same room in which the children had listened to the book.

Children received two within-category test trials first, followed by two across-category test trials. On both tests, children were shown pictures of camouflaged and noncamouflaged animals. On the within-category tests, the test stimuli belonged to the same category as the animal in the picture book (frogs). On the across-category tests, the animals belonged to a different category than the animal in the book (butterflies). In each category, the pictures showing two similar-looking animals (e.g., two green frogs) were presented first, followed by pictures of two different-looking animals (e.g., brown grass frog and orange tree frog).

On each test trial, the experimenter placed the picture of the hawk in front of the child, ''Do you remember this bird? It's still hungry and is looking for something to eat.'' Then she placed a pair of pictures of the prey animals (frogs or butterflies, with side counterbalanced over trials) below the image of the bird and asked the child, ''Which one will the bird eat?''

After the fourth trial, the experimenter re-presented a pair of pictures on which the child had earlier made a correct choice and asked him or her to justify the choice (all children made at least one correct choice). Pointing to the noncamouflaged animal, she first asked, ''You said the bird would eat this one. Why?'' After the child responded, she pointed to the camouflaged animal and asked the second justification question, ''Why won't the bird eat this one?'' Only neutral feedback was provided. The order of the justification questions was fixed.

Coding and Reliability

Choice. A choice was counted correct if the child chose the noncamouflaged animal in response to the question of which animal the predator bird would eat.

Explanations. Children's explanations of why the predator bird would or would not eat a prey animal were coded with respect to three categories:

Camouflage: A response was coded as ''camouflage'' if explicit reference was made to color camouflage as introduced in the book (e.g., ''The

bird will eat this frog, because its color is different from the dirt''; ''The bird won't eat this butterfly, because it's blue just like the flowers''). Explanations using intentional language to describe camouflage (e.g., ''The bird won't eat this frog, because the frog is *hiding* and the bird can't see it'') were coded as ''camouflage.''

Intentions or desires: These included references to the intentions or desires of the bird (e.g., ''The bird won't eat this one, because he doesn't like it''; ''The bird will eat this one, because he's hungry for it'').

Other: Justifications that could not be coded into either of the above categories (''The bird will eat it because it's juicy and yummy''; ''The bird won't eat it because it has spikes''; ''The bird won't eat it because it's blue''), no response, and ''I don't know'' responses were coded as ''other.''

Reliability. For both studies presented here, one coder coded all the children's explanations, and a second coder coded 45% of the sample. Percent agreement between the coders was 90% ($\kappa = .86$) in Experiment 1 and 87% ($\kappa = .74$) in Experiment 2. Disagreements were resolved by discussion.

Results and Discussion

Preliminary analyses indicated no effects of gender or posttest stimulus type (i.e., within vs. across category), so these factors were not included in the analyses reported here. Two sets of analyses were conducted to examine (a) children's *choice* of animal when asked the test question and (b) their *explanations* for their choices.

Choice

Table 1 shows the mean percent of correct responses given by the children in the two age groups as a function of test phase and story type. A mixed-design analysis of variance (ANOVA), with test phase as the within-subjects factor and story type and age as the between-subjects factors, revealed a significant effect of test phase, $F(1, 68) = 9.07$, $p < .01$, partial eta squared = .118. In general, the children were more likely to correctly choose the noncamouflaged animal during the posttest (72.6%) than the pretest (56.9%). The effects of story type and age were not significant, and there were no significant interactions.

An examination of individual performance patterns on the forced-choice questions reveals a significant learning effect from before to after reading the book. Data from both conditions were combined because the condition effect was not significant for either age. A paired-samples t test indicated that the 3-year-olds who scored 0 or 1 correct on the two pretest trials (25 of 40 children) were more likely to correctly choose the noncamouflaged animal after reading the book (before: 36.0% correct; after: 67.0% correct), $t(24) = 4.66$, $p < .001$ (two-tailed), Cohen's $d = 1.40$, so were the 4-year-olds who scored 0 or 1 correct at pretest (27.5% vs. 81.2% correct), $t(19) = 7.84$, $p < .001$ (two-tailed), Cohen's $d = 2.48$. The posttest performances of both age groups were significantly better than would be expected by chance (50% correct), $t(24) = 3.98$, $p < .001$, and $t(19) = 7.80$, $p < .001$, respectively (one-sample t test, two-tailed). Of the children who chose correctly on both pretest trials, most performed consistently after reading the book, making at least three correct choices on the four posttest trials.

Explanations

Each child was asked two explanation questions on both the pre and the posttests. Figure 1 shows the percentage of each explanation type, by test phase and age, with data from both book conditions combined.

The 3-year-olds seldom provided camouflage explanations, either before or after reading the book. The 4-year-olds never provided camouflage explanations before reading the book (pretest);

Table 1
Mean Percentages of Correct Choice in Experiment 1, by Book Condition, Age, and Posttest Phase

Factual book				Intentional book			
Age	*N*	Pretest	Posttest	Age	*N*	Pretest	Posttest
3	20	52.5	65.0**	3	20	67.5*	70.0**
4	16	65.0	75.0**	4	16	43.8	82.8**
Total	36	56.9	69.4**	Total	36	56.9	75.7**

*$p < .05$, **$p < .01$, compared to chance performance (50%).

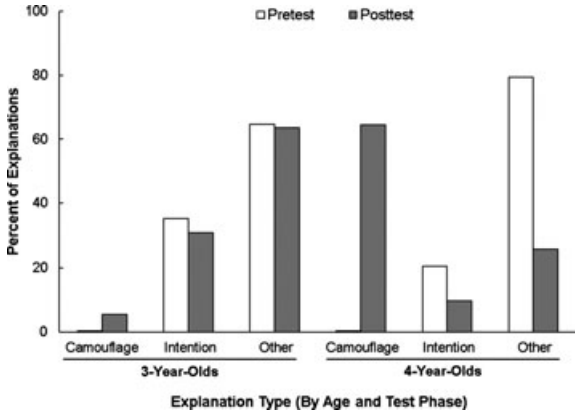

Figure 1. Percentage of children's explanations in each category, by age and test phase (Experiment 1, with data from both book conditions combined).

however, after reading the book, they often justified their response to the choice questions by referring to the color match between the animal and the background (64.1%). The 4-year-olds in the intentional book condition provided somewhat more camouflage explanations (75.0%) than did those in the factual book condition (53.1%). Only four of the children who listened to the intentional story framed the camouflage explanation in intentional terms.

To summarize, the results of Experiment 1 showed that children as young as 4 years of age can learn, generalize, and explain new biological facts from a brief picture-book interaction. After listening to a book that illustrated and described color camouflage in frogs, children used the information to explain a similar situation involving novel animals (butterflies). Their performance was equally good with the factual and the intentional books. The 3-year-olds correctly indicated which animal would fall prey to a predatory bird significantly more often after being exposed to the story than before, but they did not invoke color camouflage in explaining their choice.

Experiment 2

In Experiment 2, we assessed whether 4-year-olds can transfer information about biological camouflage from a picture book to *real* animals. The children first listened to a book about lizards that explained biological color camouflage using either factual or intentional language. Their learning from the book was first assessed using pictures of novel animals, and then they were presented with real animals (lizards and crabs) in camouflage or noncamouflage settings and asked to indicate which of the animals would be more likely to fall prey to a bird. They were also asked to select a ''safe home'' for a *real* animal, choosing from displays that either matched or did not match the color of the animal.

Method

Participants

The final sample included thirty-two 4-year-olds (M = 53.5 months, range = 48.5–59.5 months), with equal numbers of girls and boys. Nine additional children were excluded, because of prior knowledge of camouflage as determined at pretest (7), sibling interference (1), or experimenter error (1). The majority of children came from white, middle-class families.

Materials

Pretest stimuli. Two pairs of color photographs were used for the pretest as in Experiment 1. One pair depicted two different-looking frogs, and the other pair depicted two different-looking butterflies. In each pair, one animal was camouflaged (difficult to see against the background), and the other one was not (highly visible against the background).

Picture books. The structure of the stories in the books was very similar to the books used in Experiment 1 (see Appendix A). One book used *factual* language and the other used *intentional* language to explain why a predator bird could or could not find a lizard.

Posttest stimuli. Four live animals (two lizards and two crabs) and two pairs of color photographs of lizards and crabs were used during the posttest. Four tanks and two small plastic cages housed the animals. A picture of the predatory bird from the books was also used.

Picture test: Two pairs of pictures depicting animals in camouflaged versus noncamouflaged settings were used for the two picture trials. One pair of pictures depicted within-category animals (lizards), whereas the other pair was of animals not depicted in the book (crabs). A picture of the bird from the book was also used.

Real animal choice test: Two pairs of live animals in camouflaged versus noncamouflaged settings (see Appendix B for examples) were used for this test: within category (lizards) and across category (crabs).

Real animal placement test: Two pairs of tanks displayed camouflage versus noncamouflage habitats, with no animals in them. In the first pair, one tank contained sand that was the same color as one of the real lizards, and the other tank contained sand in a quite different color. In the second pair, one tank contained gravel in the same color as one of the real crabs, and the other tank contained gravel in a different color. A lizard and a crab were each placed in small transparent containers.

Procedure

The *pretest* and *book-reading* sessions were the same as in Experiment 1. Children's knowledge of camouflage was first tested with two questions involving photos of camouflaged and noncamouflaged frogs and butterflies, and then they listened to a picture book that explained and illustrated color camouflage in lizards. The *posttest* phase included three parts assessing the children's learning and transfer of the information from the book. All children received the picture test first, in the same room in which they read the book, which made possible comparison of results to Experiment 1, in which children were tested with pictures in the same room in which they listened to the book. The tests involving the real animals were administered in a different room to more closely approximate a real life situation, in that typically children do not see the entities depicted in a book in the same place in which they read the book. The order of the real animal choice test and the real animal placement test was counterbalanced within book condition. As in Experiment 1, children were asked two justification questions for each type of test (one question was about why the bird would eat the noncamouflaged animal, and the other question was about why the bird would not eat the noncamouflaged animal). Thus, children received six justification questions at posttest.

Picture test: The two picture trials were conducted in the same way as in Experiment 1. The within-category (lizard) trial was conducted first, followed by the across-category (crab) trial. At the end of the second trial, the experimenter asked the children to justify their choice on one of the trials on which they responded correctly as in Experiment 1. Then the child was taken to a nearby room for the real animal trials (animal choice and placement).

Real animal choice test: On two trials, the children were asked to choose which of two real animals (one camouflaged and one not camouflaged) would be more likely to be eaten by a bird. The within-category (lizard) trial was conducted first, followed by the across-category (crab) trial. On each trial, after drawing the child's attention to the animals in the two tanks and placing the picture of the bird in the middle in front of the two tanks, the experimenter asked the child, ''This bird is still hungry. It's looking for a lizard/crab to eat. Which lizard/crab will the bird eat—this one or this one (pointing to each tank)?'' After the second trial, the experimenter asked the child to justify his/her answer for a pair of animals for which the child had made a correct choice. While directing the child's attention to the corresponding tanks, the experimenter asked: ''You said the bird would eat this one. Why?'' After the child responded, the experimenter pointed to the camouflaged animal and asked, ''Why won't the bird eat this one?''

Real animal placement test: In this test, children were asked to choose a ''safe home'' for the real animal from two display tanks (one that matched the color of the animal and one that did not). The within-category (lizard) trial was conducted first, followed by the across-category (crab) trial. On each trial, the experimenter first drew the child's attention to the two tanks, pointed to the picture of the bird and said, ''This bird is still hungry. It's looking for a lizard/crab to eat. Where should we put the lizard/crab so it can be safe from the bird, here or here (pointing to each tank)?'' At the end of the second trial, the experimenter asked two justification questions.

Coding

The coding of children's choices and explanations was the same as in Experiment 1.

Results and Discussion

Preliminary analyses indicated no effect of test order (real animal choice vs. animal placement) or posttest stimulus type (within- vs. across-category) during the posttest.

Choice

Table 2 shows the percentage of correct responses by story type (factual vs. intentional), test phase (pre vs. posttest), and posttest type (picture vs. real animal choice and animal placement).

Picture trials: Pre- versus posttest comparison. The mean percentages of correct choices were examined in a mixed-design ANOVA, with the test phase as the within-subjects factor, and story type and gender as the between-subjects factors. There was a

Table 2
Mean Percentages of Correct Choice in Experiment 2, by Book Condition, Test Phase, and Posttest Type

Factual book					Intentional book				
		Posttest					Posttest		
N	Pretest: Picture	Picture	Choice	Placement	*N*	Pretest: Picture	Picture	Choice	Placement
16	62.5	90.6**	65.6	62.5	16	62.5	84.4**	87.5**	65.6

**$p < .01$, compared to chance expectation (50%).

significant main effect of test phase, $F(1, 28) = 10.93$, $p < .01$, partial eta squared = .281. In both the factual book and the intentional book conditions, children correctly chose the noncamouflaged animal on the picture trials more often after reading the book (90.6% and 84.4%, respectively) than before (62.5% in both conditions). The effect of gender was also significant, $F(1, 28) = 5.80$, $p < .05$, partial eta squared = .172. Post hoc tests indicated that the gender effect was mainly due to children's performance at pretest, with the girls choosing the noncamouflaged animal more often (75%) than the boys (50%). The main effect of story type was not significant, nor were any of the interactions. There was no significant gender difference during the posttest phase. In both book conditions, the children's performance on the picture trials during the posttest was comparable to that of the 4-year-olds in Experiment 1.

The individual performance analysis on the picture test also revealed significant changes in children's performance from pretest to posttest. Data were combined across conditions because there was no significant condition effect. A paired-samples *t* test showed that the 4-year-olds who scored 0 or 1 at pretest (19 of 32 children) were more likely to correctly choose the noncamouflaged animal after reading the book than before (before: 36.8% correct; after: 79.0% correct), $t(18) = 4.09$, $p < .01$ (two-tailed), Cohen's $d = 1.59$. Their posttest performance was significantly better than would be expected by chance (50% correct), $t(18) = 4.16$, $p < .01$ (one-sample *t* test, two-tailed). All of the children who chose correctly on both pretest trials (13 of 32 children) also made correct choices on both posttest picture trials.

Performance across the three posttest types. With test type (picture vs. real animal choice vs. animal placement) as the within-subjects factor and story type and gender as the between-subjects factors, a mixed-design ANOVA revealed a significant main effect of test type, $F(1, 28) = 8.46$, $p < .01$, partial eta squared = .232. Post hoc tests revealed that children responded correctly on the picture trials (87.5%) more often than on the animal placement trials (64.1%), $t(31) = 2.90$, $p < .01$ (paired-samples *t* test, two-tailed), Cohen's $d = .65$. The difference in their performance on the picture trials versus on the real animal choice trials (76.6% correct) was marginally significant, $t(31) = 1.75$, $p = .09$ (two-tailed). The effect of gender was also significant, $F(1, 28) = 4.45$, $p < .05$, partial eta squared = .137, with the girls responding correctly (85.4%) more often than the boys (66.7%). The effect of story type was not significant, and there were no significant interactions.

Explanations

The child was asked two explanation questions during the pretest, and six questions during the posttest (two for each of the three types of test trials). In general, children provided camouflage explanations substantially more often after reading the story (58.3% for the factual story and 62.1% for the intentional story) than before reading the story (3.1% and none, respectively). As in Experiment 1, very few children who listened to the intentional story provided camouflage explanations in intentional terms ($n = 3$).

General Discussion

This research has shown that by the age of 4 children can learn new biological facts from a picture book that they can then apply to depictions of new animals and even to live animals. For example, when asked to indicate which of two live animals would be more likely to fall prey to a predatory bird, the 4-year-olds correctly indicated the animal whose color did not match the background, and justified their choice by explicitly referring to information encountered in the book about color camouflage. When asked to choose a safe place for a live animal to live in, some children

also considered whether the color of the animal matched the test displays.

Nevertheless, children's ability to transfer new biological facts from a picture-book context to live animals has some limitations. Across the three types of posttest questions in Experiment 2, 4-year-old children performed better when tested with pictures than with real animals. This finding is consistent with recent research showing that generalization from picture books to the real world can be tenuous for young children, specifically, that their generalization can be affected by the level of similarity between depicted and real objects (Ganea et al., 2008; Ganea et al., 2009; Simcock & DeLoache, 2006) and by the level of match between the context in which they read the book and the context in which they are tested (Simcock & Dooley, 2007).

The fact that children's performance deteriorated when tested with real animals is consistent with the proposal that young children encode specific contextual cues in their memory representation of new information and that altering those contextual cues can have a negative impact on their retrieval performance (Hayne, 2004; Learmonth et al., 2004). In addition to changes in medium (from pictures to real animals), the tests involving real animals were conducted in a different room than the room in which children read the book. This testing situation resembles a real life situation in that typically children do not see the entities depicted in a book in the same place in which they read the book. For example, if children are exposed to new facts about giraffes, they would probably not get to apply that information until their next visit to the zoo. According to Barnett and Ceci's (2002) analysis of transfer, very few developmental studies have examined *remote* transfer involving a test that is conducted several months later, by a different experimenter and in a completely different context than the one encountered at learning. Thus, ideally, we would want to test children's transfer of biological camouflage several weeks or even months after being exposed to the information in a picture book and in a very different setting, such as during a trip to the local zoo.

The 3-year-olds in Experiment 1 did not refer to color camouflage when asked to explain why they selected the depiction of the target animal. Nevertheless, after exposure to the picture book, they more often indicated that a noncamouflaged animal would fall prey to a predatory bird than that a camouflaged one would. At a basic level this indicates that children did not encode the information as specific to the animals depicted in the book, but rather as something that could be generalized to depictions of novel animals. What the children did not do was provide reasons for the particular choices they made. Future research could determine whether 3-year-olds might show evidence of a higher level of learning if tested on a task with reduced cognitive demands (e.g., forced-choice justification questions).

To explain the 3-year-olds' limited performance in this research, we can also draw on findings from the literature on analogy (Brown & Kane, 1988; Gentner & Loewenstein, 2002; Loewenstein & Gentner, 2001). It is possible that 3-year-olds may need more experience with different examples illustrating the information (e.g., different types of animals that are using color camouflage), and with drawing explicit verbal inferences based on their picture-book experience. In the current research, children saw only one type of animal depicted in the book and they were offered no information other than what was presented during the story. Prior research has shown that novice learners benefit from multiple exemplars that illustrate the general mechanism or concept (Brown & Kane, 1988; Gentner, Loewenstein, & Thompson, 2003). Thus, books that show different examples of a given mechanism would provide young children with more opportunities to notice deeper similarities between examples, thereby facilitating transfer to a novel situation. Furthermore, children's generalization from a book may also be influenced by a more interactive ''dialogic'' reading style in which the child is prompted to ask questions throughout the book reading (Whitehurst & Lonigan, 1998).

Another goal of this research was to examine the effect of embedding biological information in factual versus intentional formats. Thus, we manipulated whether the mechanism of color camouflage was described in factual terms or in intentional language (attributing human reasoning and intentions to animals and personifying them with names). Children at both ages remembered and used the biological information from both types of stories to correctly identify the noncamouflaged animal at posttest. The 4-year-olds were also able to answer factual questions involving the use of the biological facts presented in both book conditions. Some researchers have proposed that young children naturally tend to attribute human reasoning to animals (Carey, 1985; Kelemen, 1999). It is thus possible that providing children with explanations in a framework that matches their predominant mode of reasoning makes those explanations memorable and comprehensible. One possibility that should be examined in future research is that, even though an anthropomorphic framework may resonate with children's initial construal of animals and as a

result help them retain and generalize the biological facts, over time embedding the biological facts in an intentional framework may not facilitate causal biological understanding. Support for this possibility comes from recent research showing that anthropomorphic language may influence children's understanding of evolutionary change (Lane, Legare, French, Kiss, & Evans, 2009).

Further research is needed to clarify the effect of embedding scientific information in an anthropomorphic framework on children's learning and transfer from books to the real world. In the research reported here, the animals were depicted in a highly realistic manner. With less realistic depictions, such as those commonly found in commercial picture books for young children (e.g., animals walking upright on two feet and wearing clothes), children might be less likely to learn and transfer the scientific content from books to real animals. Thus, important questions remain regarding the effect of different types of depictions and language in children's books on their beliefs and reasoning about the world.

To summarize, the research presented here has shown that by the age of 4, children can acquire simple factual information about the biological world from a picture-book interaction that they can then use to explain a real situation involving live animals. This research points to the importance of early book exposure in framing and increasing children's knowledge about the world. Increased understanding of the factors involved in young children's learning and transfer from books to reality can help us devise more effective ways of teaching simple scientific concepts early in life.

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Appendix A

Factual and Intentional Story Script

(a) Factual Story	(b) Intentional Story
Some frogs live in water. They are good swimmers.	This is Sammy the frog. Sammy likes to swim a lot!
Some frogs live on the ground. They stay around grass and leaves.	Sammy also likes to be in the grass.
Frogs have big, strong back legs. They are good jumpers!	Sammy has big strong legs. Sometimes he gets very naughty and starts jumping around!
This green frog is sitting on a green leaf. It's basking in the sun. Look! The frog is the same color as the green leaves!	Here Sammy is sitting on a leaf enjoying the sunshine. Look! Sammy's color is the same as the green leaves!
The green frog is now sitting in a tree with pink flowers.	Sammy likes to smell the sweet flowers on this tree. Look,
Look! Its color is different from the pink flowers.	Sammy's color is different from the pink flower.
This is a bird that lives on a tree. Birds eat frogs!	This is a bird that lives on a tree. He likes to eat frogs!
This bird is flying high in the sky. It's hungry and is looking for something to eat.	Look, the bird is flying high in the sky. He's very hungry, so he's trying to find a frog to eat.
Will the bird find the frog? Sometimes it can be hard to see frogs. Can you see the frog on the green grapes? It's hard to see it because it's green just like the green grapes.	Will the bird find Sammy the frog? Sammy hides among the green grapes. How smart he is! It's hard to see Sammy because he's green just like the grapes.
Now the green frog is sitting on this green plant. It's hard to see it, isn't it? Its color is the same as the green leaves!	Look, Sammy is now hidden among these green leaves. It's hard to find Sammy, isn't it? His color is the same as the green leaves!
The bird is still looking for something to eat. But, the bird doesn't see the frog because it's the same color as the things around it. So, the bird flies away.	The bird doesn't see Sammy because Sammy's color is the same as the things around him. Sammy tricked the bird! So, the bird flies away.
The bird goes back to the tree to rest. But, it's still hungry!	The bird goes back to his tree to rest. But, he's still hungry!
Look! The bird is flying again. It's looking for something to eat!	Look, the bird goes flying again. He really wants to find a frog to eat! Will the bird find Sammy?
Will the bird find the frog? Sometimes it can be easy to see frogs. Can you see the frog on the purple flower? It's easy to see it because its color is different from the purple flower.	Oh no! Sammy forgets to hide! Now it would be easy for the bird to see Sammy. Can you see Sammy on the purple flower? It's easy to see Sammy because his color is different from the purple flower.
Now the green frog is sitting on a red tree log. It's easy to see it, isn't it? The color of the frog is different from the red log.	Oh no! Sammy is almost asleep on the red log and doesn't have time to trick the bird! It's easy to see Sammy, isn't it?
Because the color of the frog is different from the color of the things around it, the bird sees it and comes to catch it!	His color is different from the red log.
Remember! When the color of the frog is the same as the color of the things around it, the bird doesn't see it and flies away.	Because Sammy's color is different from the things around him, the bird sees him and comes to get him!
	Remember! When Sammy's color is the same as the color of the things around him, the bird can't see him and flies away.

Appendix B

Examples of real animal (within-category) stimuli used in Experiment 2 in which children were exposed to a book about biological camouflage in lizards.