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Infants transfer nonobvious properties from pictures to real-world objects

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ABSTRACT

The current research examined infants' ability to generalize information about the nonobvious properties of objects depicted in picture books to their real-world referents. Infants aged 13, 15, and 18 months ($N = 135$) were shown a series of pictures depicting an adult acting on a novel object to elicit a nonobvious property of that object. Infants were subsequently tested on their extension of the nonobvious property to the real-world object depicted in the book and their generalization of this property to a different color exemplar of the depicted object. Results indicated that, regardless of age, infants expected the real-world objects to have the nonobvious property, as indicated by their attempts to elicit this property with these objects. These findings indicate that early in their second year of life, infants are beginning to make inductive inferences about nonobvious object properties based on information provided in pictures.

Introduction

Inductive reasoning involves making an inference about the properties of one category member based on knowledge of the properties of another member of the same category (see Hayes, Heit, & Swendsen, 2010, for a review). The ability to reason inductively emerges during infancy, as evidenced

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by infants' willingness to generalize a nonobvious property of one object to another object if they view them as belonging to the same category (Baldwin, Markman, & Melartin, 1993; Welder & Graham, 2001). In this experiment, we asked whether 13-, 15-, and 18-month-old infants would draw inductive inferences about real objects based on information presented symbolically during a picture book interaction.

Much of what we know about infants' inductive reasoning is based on studies using imitation paradigms in which an experimenter performs an action on a target object that elicits a nonobvious property (Baldwin et al., 1993). If infants view the target and test objects as belonging to the same category, they will expect the test objects to share the nonobvious property and imitate the target action to trigger the property. Thus, infants' imitation of the target action on the test objects provides evidence of inductive reasoning. Using this paradigm, studies have demonstrated that inductive reasoning skills are present as early as 9 to 13 months of age (Baldwin et al., 1993; Graham, Kilbreath, & Welder, 2004). Furthermore, infants will rely on information about category membership, in the form of shared count nouns or shared perceptual similarity, to determine whether two objects belong to the same category and share nonobvious properties (Graham & Diesendruck, 2010; Graham & Kilbreath, 2007; Graham et al., 2004; Keates & Graham, 2008; Welder & Graham, 2001).

In the current research, we extended the examination of inductive reasoning during infancy in a novel direction by asking whether infants apply their inductive reasoning skills in the symbolic domain. The ability to draw inferences from symbolic artifacts is a critical skill that enables us to acquire novel information about the environment indirectly. The specific focus here was on whether infants make inferences about nonobvious object properties based on their knowledge of the objects from picture books. Pictures are among the most common symbols to which children are exposed very early in life (DeLoache & Ganea, 2009), and a growing body of research indicates that infants begin to understand their referential nature by the middle of their second year of life (Ganea, Allen, Butler, Carey, & DeLoache, 2009; Ganea, Bloom Pickard, & DeLoache, 2008; Preissler & Carey, 2004; Simcock & DeLoache, 2006, 2008; Simcock & Dooley, 2007).

Beginning in their first year of life, infants discriminate between objects and their two-dimensional representations (DeLoache, Strauss, & Maynard, 1979; Field, 1976; Rose, 1977) and perceive similarities between objects or people and their pictorial representations (DeLoache et al., 1979; Dirks & Gibson, 1977). Despite these early accomplishments, however, 9-month-olds will manually explore depicted objects, suggesting that they do not understand how pictures differ from their referents (DeLoache, Pierroutsakos, Uttal, Rosengren, & Gottlieb, 1998; Pierroutsakos & DeLoache, 2003). By 19 months of age, infants will point at and label depictions, indicating that they have begun to understand their referential nature—the fact that they can represent objects and situations in the real world (DeLoache & Burns, 1994). Further evidence of the emergence of pictorial competence during the second year of life comes from studies demonstrating that 15- to 24-month-olds will extend newly learned labels for depicted objects to their referents (Ganea et al., 2008, 2009; Preissler & Carey, 2004). For example, Ganea and colleagues (2008) showed that 15- and 18-month-olds will extend newly learned labels from realistic pictures to their real-world referents. The 18-month-olds also generalized the novel name to a new exemplar, suggesting that they interpreted the depicted object as representing a class of objects, not just an individual object. Overall, children were more likely to transfer the label from a depiction to its real referent with highly realistic pictures than with less realistic depictions (e.g., drawings, cartoons).

By 18 months of age, children can imitate a sequence of actions on novel real-world objects on the basis of a picture book interaction, demonstrating sophisticated reasoning from a symbolic source (Simcock & DeLoache, 2008; Simcock & Dooley, 2007). In one study, 18-, 24-, and 30-month-olds were shown a picture book depicting how to construct a novel object (a rattle) and subsequently tested on their ability to reenact the novel action sequence with real objects (Simcock & DeLoache, 2006). Children's reenactment scores varied as a function of age and the iconicity of the pictures. There was a significant increase in the number of depicted target actions produced by each successive age group, and the 18-month-olds imitated target actions primarily after seeing highly realistic photographs in the book. Critically, toddlers who had not seen a live demonstration or picture book illustrating the action sequence did not construct the novel object, demonstrating that the objects themselves did not afford the actions. In a subsequent study, Simcock and Dooley (2007) found that 18-month-olds would imitate an action sequence from a book only when the test context and stimuli matched those depicted in the book. That is, when tested in a different room or presented with stimuli that differed in color from those depicted in the book, 18-month-olds' imitation of the action sequence did not differ from that of no-demonstration controls. In contrast, 24-month-olds generalized the action sequence with changes to both the test context and stimuli. These results represent an important extension of the literature on children's ability to use pictures symbolically by demonstrating that 24-month-olds will generalize novel actions that are depicted in pictures to novel test conditions.

Together, the studies reviewed above demonstrate that children as young as 15 months can transfer new information (e.g., new label, novel action sequence) from a picture book to its real-world referents. In this experiment, we asked whether this ability can be revealed at an even earlier age and in the context of learning about a nonobvious property of a depicted object. To date, infants' category-based inductive reasoning skills have been studied only with real objects. Given the importance of symbols for learning about the world indirectly, it is important to establish whether infants can apply their inductive reasoning skills across domains—from symbols to their real referents. Thus, our question differs from that of previous studies that have investigated infants' transfer of information from pictorial symbols to real referents. First, we tested infants as young as 13 months, the youngest age group tested to date. Second, we examined whether infants will *categorize* a depicted stimulus and its real counterpart as belonging to the same category because of a shared nonobvious property. Here we use the term *nonobvious property* to refer to a property that is not immediately available on visual inspection, that is structurally independent (i.e., not afforded by a part of the object or the texture of the object), and that is intrinsic to the objects (i.e., a part of the object).

In this experiment, we used an inductive task in which infants are shown a nonobvious property of a depicted target object that is elicited by a particular action performed on it and at test are presented with the exact object that had been depicted in the book and a distracter object, followed by a novel exemplar of the depicted object. This inductive task differs from the imitation procedure used by Simcock and colleagues (2007, 2008) in a number of ways. First, infants were required to execute only one target action, rather than a series of actions, to demonstrate transfer of the nonobvious property. This allowed us to test younger infants. Second, the property to be evoked was an intrinsic part of an object rather than the construction of a new object. Third, infants were presented with two stimuli at test: the real-world counterparts of the depicted target object and the unrelated object. This allowed us to assess the specificity of infants' inferences. That is, we examined whether infants would attempt to elicit the depicted property of the target object versus imitating the depicted action on any object. Finally, in our task, infants were not provided with any language linking the information presented in the picture book to the real-world objects. In previous studies, the narrative of the picture book ("She can use these things to make a rattle"; Simcock & DeLoache, 2006, p. 1353) provided a label for the novel object, and this label was then used in the imitation instructions ("You can use these things to make a rattle. Show me how you can use these things to make a rattle"; Simcock & DeLoache, 2006, pp. 1353–1354).

In the context of a picture book interaction, 13-, 15-, and 18-month-olds in the current research were shown a series of pictures depicting how to elicit a nonobvious property with one of two novel objects (target object and non-target object). Infants were subsequently tested on their extension of the property to the exact target object that had been depicted in the book (extension test) and their generalization of this property to a different color exemplar of the depicted target object (generalization test). Infants' imitation of the depicted target action on the two novel objects was measured to assess their expectations about the generalizability of the nonobvious property. If infants viewed the target object and the novel exemplar as belonging to the same category as the depicted target object, they would expect the objects to share the nonobvious property and attempt to trigger it. Infants' attempts to elicit the nonobvious property in this condition were compared with infants' behaviors in a baseline condition where they interacted with a picture book that showed the target object but did not depict its nonobvious property. This comparison allowed for the assessment of infants' expectations about shared object properties. That is, if infants attempted to elicit the property of the depicted target object on the real target objects in the experimental condition (where they learned about the property of the target object through the picture book) but not in the baseline condition (where they did not know about the property), this would provide evidence that infants were indeed transferring information learned from the pictures to their real-world referents. This comparison would also indicate whether the properties of the target objects were nonobvious to infants. If infants attempted the nonobvious property with the target objects in the experimental condition but not in the baseline condition, this would ensure that the target objects did not suggest their properties through their appearances.

Our predictions for infants' performance varied according to condition (baseline vs. experimental), age (13- vs. 15- vs. 18-month-olds), and test (extension vs. generalization). First, we predicted that 15- and 18-month-olds in the experimental condition would be significantly more likely than infants in the baseline condition to extend the nonobvious property to the target object on the extension test, as evidenced by their target actions on this object. Second, we predicted that 18-month-olds, but not 15-month-olds, in the experimental condition would generalize the nonobvious property of the depicted target object to its different color target exemplar. This prediction followed from prior evidence that 15-month-olds do not generalize a novel name for a depicted object to a novel exemplar (Ganea et al., 2008). Given that even younger infants have the ability to view two real objects as belonging to the same category and assume the objects share nonobvious properties (Graham et al., 2004; Keates & Graham, 2008), the failure of 15-month-olds to generalize across modalities would suggest that these infants did not view the depicted target object and the novel exemplar as belonging to the same kind.

The lack of research on 13-month-olds' ability to apply information gained from pictures to guide their behavior in the real world made it unclear what to expect regarding their performance. We predicted that there may be a developmental trend in 13- to 18-month-olds' ability to extend and generalize nonobvious object properties from pictures. More specifically, 18-month-olds may more readily transfer nonobvious object properties from depicted objects to their real-world referents than 13-month-olds. This prediction follows from research demonstrating age-related changes in infants' transfer of novel labels and action sequences from pictures across the second year of development (Ganea et al., 2008; Simcock & DeLoache, 2006).

Method

Participants

The final sample consisted of 121 infants in three age groups: 13-month-olds ($n = 40$), 15-month-olds ($n = 40$), and 18-month-olds ($n = 41$). Infants in each age group were randomly assigned to one of two conditions: the experimental condition ($n = 61$) or the baseline condition ($n = 60$). An additional 16 infants were excluded for excessive fussiness ($n = 9$), parental interference ($n = 6$), or experimenter error ($n = 1$). Infants were recruited from health clinics, child-care centers, and trade shows in a large city. Infants were primarily Caucasian, from socioeconomic backgrounds that varied broadly within the more general middle class (although the latter was not formally assessed), and from homes in which English was the primary language spoken. See Table 1 for demographic information.

Materials

Two object sets were created: a light object set and a box object set (see Fig. 1 for photographs of the adult eliciting the nonobvious properties with the target objects and exploring the non-target objects from the box object set). Each set contained two target objects that were identical in all ways except color and two non-target objects that also differed in color only. In each set, the two target objects possessed a visually distinctive nonobvious property that could be evoked with a specific action; the objects in the box set opened and a ribbon inside them popped up, whereas the objects in the light set lit up when pushed on top. In each set, the non-target objects did not possess a nonobvious property.

Four books (25×30 cm) were constructed (two for the experimental condition and two for the baseline condition), each with 12 color photographs: six photos of one of the novel target objects and six photos of one of the non-target objects. See Figs. 1 and 2 for examples of books used in the

Table 1
Mean age, mean productive vocabulary size, and gender distribution by condition and age group.

Condition	Age group[a]	Mean age[a]	Age range[a]	Mean CDI[b]	CDI range[b]	Gender
Experimental Label						
	13 months	13.5 (0.23)	13.1–13.9	5.0 (8.3)	0–38	11 male; 9 female
	15 months	15.5 (0.28)	15.0–15.9	12.0 (13.8)	0–56	10 male; 10 female
	18 months	18.5 (0.33)	18.0–18.9	86.4 (94.3)	0–318	11 male; 10 female
Baseline						
	13 months	13.4 (0.26)	13.0–13.9	9.1 (12.2)	0–55	10 male; 10 female
	15 months	15.4 (0.27)	15.0–15.9	28.0 (33.4)	0–146	10 male; 10 female
	18 months	18.4 (0.31)	18.0–18.9	61.2 (83.7)	0–376	10 male; 10 female

[a] In months. Standard deviations are in parentheses.
[b] Number of words produced. Standard deviations are in parentheses.

experimental and baseline conditions. The adult's actions with the objects in the book varied according to condition. In the experimental condition, the adult performed an action on the target object. This action then elicited a hidden or nonobvious property of the object. In the baseline condition, the adult explored the target object without performing an action. Thus, the object's nonobvious property was not depicted. In both conditions, the adult explored the non-target object without performing an action on the object. Accompanying narration was typed and provided below each picture. The same target and non-target objects were used in the experimental and baseline conditions. Each photo (19×13 cm) of the novel objects was presented individually on 22×29-cm laminated pages. When the book was open, a picture of one novel object was visible on the right side of the book.

Design

Infants were randomly assigned to the experimental or baseline condition. In both conditions, infants were presented with two picture books, each consisting of a book reading phase followed by a test phase. On each trial, the infant was presented with one of two picture books depicting an adult interacting with a novel target and a non-target object, followed by an extension and generalization test. The order of presentation of the target and non-target objects in the picture book was counterbalanced across infants. In the experimental condition, the depicted target object had a nonobvious property that was elicited by the adult's actions with the object, whereas the non-target object did not have a nonobvious property. In the baseline condition, the adult explored both the target and non-target objects without performing an action. For each target and non-target object, the order of presentation of the six pictures in the book remained fixed.

Procedure

Each infant was seated in a booster chair or on a parent's lap across a table from the experimenter. Each child's parent was present in the testing room for the duration of the session. All sessions were videotaped for coding purposes. The procedure had two phases for each picture book trial: book reading and test.

During the book reading phase, the experimenter sat next to the infant. First, the experimenter explained that a girl named Heather had found some toys and they were going to look at these toys. Then the experimenter began to read the book while pointing to each depicted object. The experimenter monitored the infant's focus of attention and ensured that the infant looked at each depicted object.

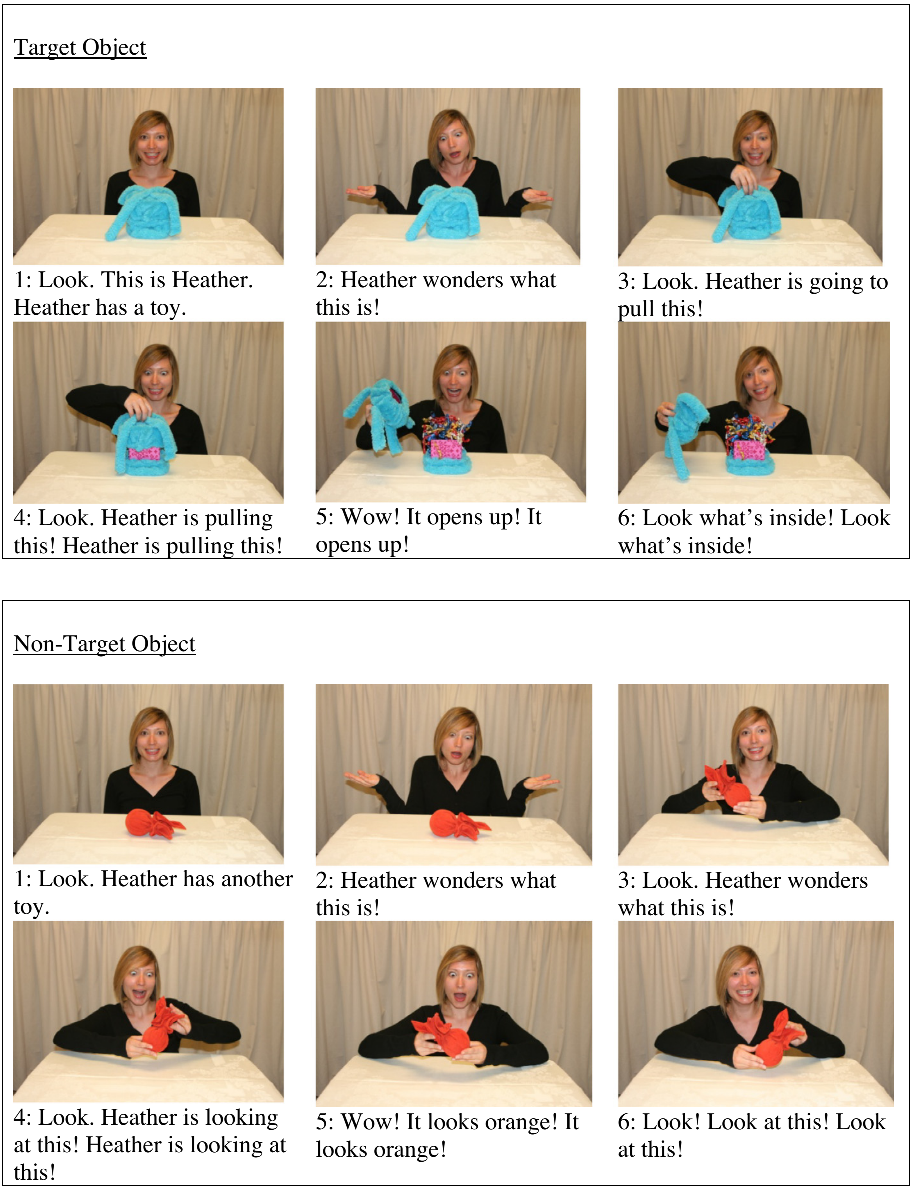

Fig. 1. Picture book for box object set: Experimental condition.

The experimenter spent approximately the same amount of time talking about each depicted novel object.

After the experimenter finished reading the book, the infant was given two tests: the extension and generalization tests. In keeping with other research (Ganea et al., 2008; Henderson & Graham, 2005; Namy, 2001; Namy & Waxman, 1998), the *extension* test was always administered before the generalization test. During the extension test, the experimenter placed the exact target and non-target objects that were depicted in the book on the table directly in front of the infant. The infant was encouraged to play with objects with a general phrase ("Okay, now you get to play"). After 20 s had

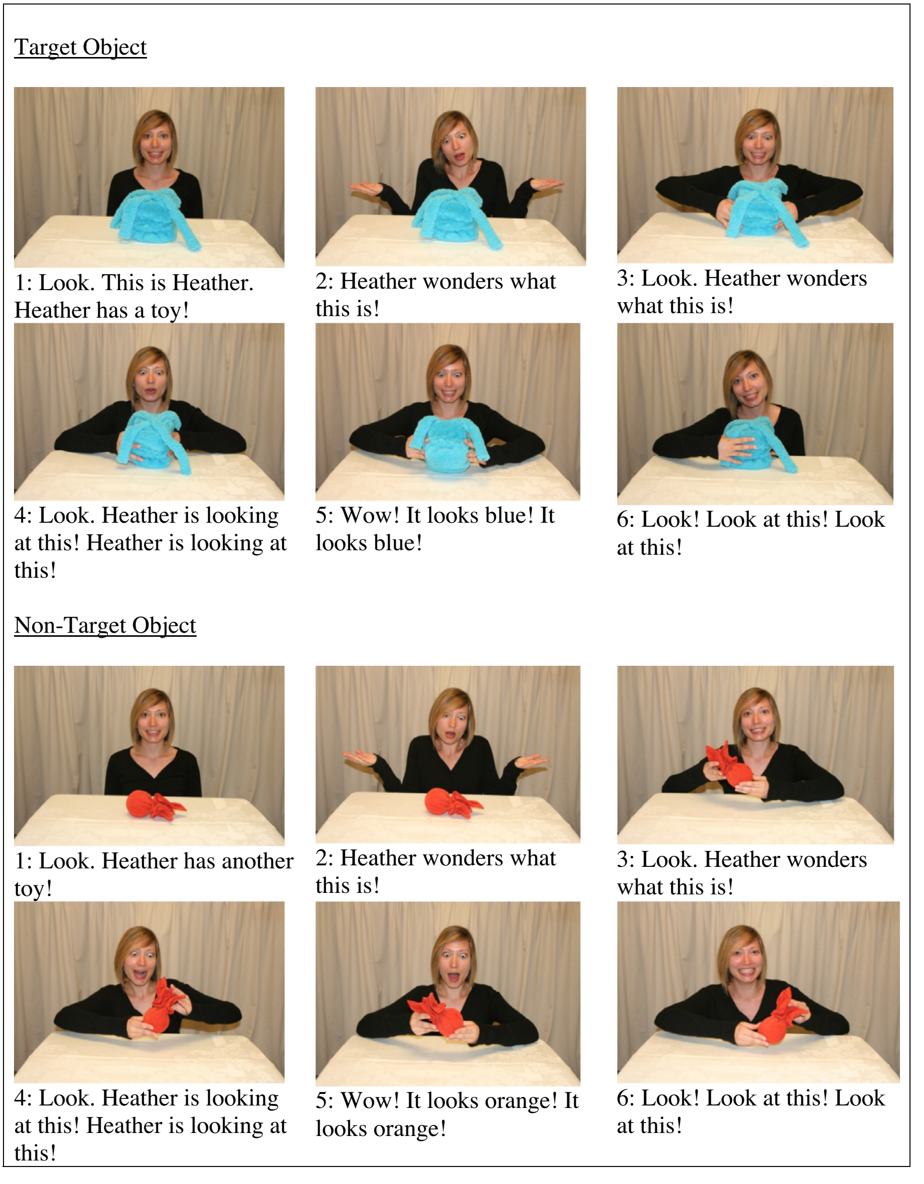

Fig. 2. Picture book for box object set: Baseline condition.

elapsed, the experimenter retrieved the two objects and began the next test. This trial provided a measure of transfer of the nonobvious property from the picture book to the real-world referent. During the *generalization* test, the experimenter placed the new exemplars of the depicted target and non-target objects on the table and similarly encouraged the infant to explore the objects ("Okay, your turn again"). This test provided a measure of infants' transfer of information beyond the referent that they had seen depicted in the book.

Once the procedure for the first picture book was completed, the experimenter proceeded to the next trials and administered both the book reading phase and the test phase in the same manner as described above.

After the infant completed the task, parents were asked to complete either the MacArthur–Bates Communicative Development Inventory (CDI): Words and Sentences (for parents of 18-month-olds) or the CDI: Words and Gestures (for parents of 13- and 15-month-olds) (Fenson et al., 2007). See Table 1 for mean productive vocabulary sizes across conditions and age groups. A 2 (Condition: experimental vs. baseline) $\times$ 3 (Age Group: 13- vs. 15- vs. 18-month-olds) analysis of variance (ANOVA) yielded a significant main effect of age group, $F(2, 115) = 17.27$, $p < .001$, $\eta_p^2 = .23$. As expected, 18-month-olds had significantly larger productive vocabularies than 15-month-olds ($p < .001$) and 13-month-olds ($p < .001$), whereas 15-month-olds did not differ significantly from 13-month-olds in productive vocabulary size. There was no main effect of condition and no interaction between age group and condition. Thus, infants in the experimental and baseline conditions did not differ significantly in productive vocabulary size.

Parents were also asked to indicate how often their infants were "read" picture books at home, with 71.1% of parents ($n = 43$ in the experimental group and $n = 43$ in the baseline group) reporting this information. Chi-square analyses revealed that the number of infants who were read picture books once, twice, or three or more times per day did not vary significantly across the experimental and baseline conditions or across the age groups ($ps > .50$). The majority of infants were being read to once or twice per day (62%), whereas fewer infants were being read to three or more times per day (36%). Only three parents (3%) reported that their infants were not read to at all.

Coding and reliability

Coders, who were unaware of the hypotheses, recorded infants' attempts to elicit the nonobvious properties by performing the depicted target actions on the target and non-target objects from the videotapes. The target action for the light object set involved tapping, hitting, or pushing on the object with the hand or fingers using a swift "tap-like" motion. The target action for the box object set involved pulling upward on the material on top of the object or pulling on the bottom of the object. The coders recorded whether or not infants performed the depicted target actions on the target and non-target objects to obtain a target action score for each trial. Recall that infants were presented with two extension tests and two generalization tests and, thus, could obtain a maximum score of two on each of these tests. Although some infants performed more than one target action on each trial, our scoring gave them credit for only one action because some infants discovered the nonobvious property with their first action and, thus, did not perform any subsequent actions. In contrast, other infants did not discover the property on their first action and performed more than one action on an object. For this reason, we used a stringent criterion and considered only whether children ever initiated the target action rather than the number of actions performed on the object.

The data were coded by assistants who were unaware of the hypotheses of the experiment. An additional coder coded 20% of the data ($n = 24$; 12 infants from each condition). Interrater reliability for target actions was high ($\kappa = .97$).

Results

Preliminary analyses indicated that infants' performance did not vary as a function of object set (light vs. box); thus, this factor was not included in any subsequent analyses. In the first set of analyses, we examined whether infants' performance of target actions on the target objects varied as a function of condition, age group, and test. Table 2 presents the mean target action score for infants in each condition and age group on the extension and generalization tests across the two trials. Recall that if infants attempted to elicit the property of the depicted target object on the real target objects in the experimental condition (where they learned about the property of the target object through the picture book) but not in the baseline condition (where they did not know about the property), this would provide evidence that infants had transferred information about the nonobvious property from pictures to real-world referents.

To examine whether infants' performance of target actions on the target objects varied as a function of condition, age group, and test, a 2 (Condition: experimental vs. baseline) $\times$ 3 (Age Group:

Table 2
Mean target action scores for target objects by condition and age group on the extension and generalization tests (scores out of 2).

Condition	Age group	Experimental	Baseline
Extension test			
	13 months	0.45 (0.60)	0.15 (0.37)
	15 months	0.70 (0.73)	0.40 (0.68)
	18 months	0.67 (0.66)	0.30 (0.57)
	Mean	0.61 (0.67)	0.28 (0.56)
Generalization test			
	13 months	0.45 (0.60)	0.15 (0.37)
	15 months	0.55 (0.60)	0.30 (0.47)
	18 months	0.57 (0.68)	0.20 (0.41)
	Mean	0.52 (0.62)	0.22 (0.42)

Note. Standard deviations are in parentheses.

13- vs. 15- vs. 18-month-olds) × 2 (Test: extension vs. generalization) mixed factor ANOVA was conducted with test as a repeated measure. This analysis yielded a significant main effect of condition, $F(1, 115) = 13.67$, $p < .001$, $\eta_p^2 = .12$. Infants in the experimental condition performed significantly more target actions on the target objects than infants in the baseline condition. There were no significant main effects of age group or test type and no significant interactions. To ensure that restriction of range on infants' scores on the dependent measure did not account for the null effect of age group, we conducted a multiway frequency analysis because this statistical procedure is not susceptible to violations of normal distributions (Tabachnik & Fidell, 2007). The results were consistent with those of the mixed factor ANOVA. These results indicate that after learning about the target object property from pictures, infants across the age groups attempted to elicit this property with the exact target object that had been depicted in the book and with the novel target exemplar. Furthermore, the results from the baseline condition indicate that the target objects did not suggest the nonobvious properties through their appearances.

Next, to ensure that infants' actions were specific to objects they viewed as referents of the pictures and to rule out the possibility that infants would imitate the depicted actions on any object, we examined infants' performance of target actions on the non-target objects. Only 6% of infants ($n = 2$ in the experimental condition and $n = 5$ in the baseline condition) performed one target action on the non-target objects on the extension test. Similarly, only 5% of infants ($n = 4$ in the experimental condition and $n = 2$ in the baseline condition) performed one target action on the non-target objects on the generalization test. No infants performed actions on more than one non-target object. An overall ANOVA comparing infants' actions on the target and non-target objects as a function of age group, condition, and test could not be performed on these data because multiple cells had zero variance. Thus, we focused our analyses on comparing infants' actions on the target and non-target objects within the experimental condition only, using the Wilcoxon signed rank test due to the extreme skewness in the non-target data. On the extension test, infants in the experimental condition performed significantly more target actions on the target object ($M = 0.52$, $SD = 0.62$) than on the non-target object ($M = 0.03$, $SD = 0.18$), $Z = -5.05$, $p < .001$. Similarly, on the generalization test, infants performed significantly more target actions on the target object ($M = 0.61$, $SD = 0.67$) than on the non-target object ($M = 0.07$, $SD = 0.24$), $Z = -4.52$, $p < .001$. These results indicate that infants in the experimental condition were more likely to perform target actions on the target objects than on the non-target objects rather than imitating the target action that had been depicted in the pictures on any type of object presented during the test phase.

In the next set of analyses, we examined whether vocabulary size, given previous reports of a correlation between children's productive vocabulary size and shape-based generalizations (Graham & Diesendruck, 2010; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002), or frequency of book reading experience may have influenced infants' transfer of the nonobvious properties. These analyses revealed no significant correlations between productive vocabulary size and performance of target actions on the test trials by infants in the experimental condition ($ps > .40$). Furthermore, there were no significant correlations between book reading frequency, as reported by parents, and performance of target actions on the test trials by infants in the experimental condition ($ps > .40$). Thus, neither vocabulary nor exposure to picture books influenced infants' transfer of nonobvious properties from pictures to objects.

Finally, although the above results indicated that infants treated the extension and generalization objects similarly, infants were always presented with the exact target objects that were depicted in the book before the different color target exemplars. Thus, it is possible that the transfer was not from the depicted object to its novel exemplar but rather from the target object presented during the extension test to the differently colored exemplar presented during the generalization test. To assess this possibility, we tested 14 new infants (mean age = 18.03 months, $SD = 0.33$, range = 18.47–18.95; 7 boys and 7 girls) in a follow-up group. These infants were recruited from the same population as infants in the main experiment. In this group, the procedure used was identical to that used in the experimental group except that infants were presented with the generalization exemplar first and the extension object second. Planned comparisons indicated that infants' performance of target actions on the generalization exemplar in this new group ($M = 0.57$, $SD = 0.64$) did not differ from that of the 18-month-olds who had received the generalization trial second, $t(33) = 0.00$, $p = 1.00$. Their performance also did not differ from that of all infants, regardless of age group, tested in the experimental condition of the main experiment, $t(73) = 0.25$, $p = .80$. Similarly, infants' performance of target actions on the extension object in this new group ($M = 0.71$, $SD = 0.85$) did not differ from that of the 18-month-olds who had received the extension trial first, $t(33) = 0.19$, $p = .85$, nor from the extension performance of all infants tested in the experimental condition of the main experiment, $t(73) = 0.19$, $p = .60$. These results suggest that infants were indeed viewing the depicted target object and the differently colored object as belonging to the same category and, thus, expected these objects to share nonobvious properties.

Discussion

This research offers a number of insights into infants' abilities to make inductive inferences about shared properties of objects. First, the results demonstrate that infants from 13 to 18 months of age transfer information about objects from pictures to their real-world referents. Infants were significantly more likely to attempt to elicit the nonobvious property with the target object and the different color target exemplar in the experimental condition (where they knew about the target property) than in the baseline condition (where they did not know about the property). Results from the baseline condition indicate that infants could not detect the property of the objects from merely interacting with the objects. This finding demonstrates that infants' actions on the objects were not the result of affordances of the objects themselves. Thus, infants in the experimental condition formed a representation of the object possessing a hidden property that could be invoked with a particular action from the two-dimensional exposure in the picture book. At test, infants then compared the real-world object with this representation (recall that the picture book was not available to the infants) and inferred that they were similar and, thus, the real-world object also shared the nonobvious property. They then attempted to elicit the nonobvious property on the real-world object using the target action. These findings suggest that infants viewed depicted objects as having inductive potential; that is, they formed an expectation that the depicted and real-world objects shared the same nonobvious property.

These results indicate an early flexibility in the nature of infants' inductive reasoning strategies in that infants can form expectations about shared object properties even when the objects are presented within different symbolic modalities. The ability to draw inferences from symbolic artifacts is a critical skill that enables infants to acquire valuable information about the environment and objects in it without directly interacting with those objects. In particular, the ability to exploit the informational potential of pictures to learn about the real entities they represent is a valuable learning strategy in part because young children have so much exposure to pictures (DeLoache & Ganea, 2009). Considered in conjunction with prior research on early induction (Graham & Diesendruck, 2010; Graham & Kilbreath, 2007; Graham et al., 2004; Keates & Graham, 2008; Welder & Graham, 2001), the current findings provide further evidence that infants possess well-developed inductive reasoning capacities during the second year of life.

We propose that infants established an expectation that the real-world objects shared the same nonobvious property as the depicted objects. It is, however, possible that infants established a more simple type of association between an object and a particular action (i.e., "If it is this shape, pat it"). Although the current data do not allow us to distinguish between these two possibilities, previous research indicates that infants are not simply developing object–action associations in inductive inference tasks. That is, studies using a similar task (but with real objects) demonstrate that infants of the same age as those tested in our work will persist in using a target action to evoke a nonobvious property on an object that has been disabled (Graham & Diesendruck, 2010; Graham & Kilbreath, 2007; Graham et al., 2004; Welder & Graham, 2001). This suggests that infants are seeking to evoke the nonobvious property rather than simply performing a specific action on a similarly shaped object. Moreover, infants will perform the target action to evoke the nonobvious property on objects that are perceptually dissimilar if they are provided with other information suggesting that these objects belong to the same category (Graham et al., 2004; Keates & Graham, 2008).

Second, 13- to 18-month-olds in the current study did not significantly differ in their tendency to transfer information from pictures to the real-world objects, suggesting an early appreciation of the referential nature of pictures and of their inductive potential. There are two possible explanations for this lack of age difference. One is that the highly realistic pictures used to depict the nonobvious object properties and the narration used to describe them possibly facilitated younger children's performance in this research. Prior research has shown that infants are relatively proficient at transferring novel information between a picture and its referent when the picture is highly realistic (Ganea et al., 2008). A second possible explanation for the lack of effect of age group is that the majority of infants in the current study were exposed to daily picture book reading and the frequency of picture book reading did not vary according to age. Thus, 13-month-olds were exposed to picture books as frequently as older infants. It has been proposed that experience with pictures allows infants to come to understand the limitations of two-dimensional objects and to begin to learn how pictures are used (Callaghan & Rankin, 2002; DeLoache & Burns, 1994; DeLoache, Pierroutsakos, & Troseth, 1996).

Third, the current findings indicate that infants' target actions on the extension object did not differ from their target actions on the differently colored generalization object. This may indicate that infants viewed the depicted target object and the differently colored object as belonging to the same category and, thus, expected these objects to share nonobvious properties. Given the role of shape similarity in guiding infants' inductions about nonobvious object properties (Graham & Diesendruck, 2010; Graham & Kilbreath, 2007; Graham et al., 2004; Keates & Graham, 2008; Welder & Graham, 2001), it is likely that infants in the current study relied on shape similarity between the depicted objects and the new exemplars to guide their inductive inferences about shared nonobvious properties.

Finally, our results indicate that although 13- to 18-month-olds will transfer nonobvious properties from pictures to real-world objects, this ability appears to be emergent during this developmental period. The mean number of target actions performed by infants in the experimental condition fell at the lower end of the range of possible target actions that could be performed. Of a maximum number of two target actions that could be performed, approximately half of infants in the experimental condition did not perform a target action on the extension (49%, 30 of 61) and generalization (54%, 33 of 61) tests. In this condition, 41% (25 of 61) and 39% (24 of 61) of infants performed one target action on the extension and generalization tests, respectively. Relatively few infants performed two target actions on these tests (extension: 10%, 6 of 61; generalization: 7%, 4 of 61). Thus, many infants in the experimental condition had difficulty in succeeding on the test trials. This finding may be due, in part, to the motoric requirements of the task in that children needed to execute specific actions on the objects. This finding may also suggest that infants' understanding of pictures as an inductive source is fragile at this young age despite evidence that by 15 months they have begun to appreciate their referential nature (Ganea et al., 2008; Preissler & Carey, 2004).

The current study allowed us to move beyond examining infants' ability to learn words for depicted objects or reproduce actions learned in a book to examining whether infants would view depicted objects as having inductive potential. That is, by using the pictorial induction task, we were able to address the inferencing question—whether infants would make *inductive inferences* about nonobvious object properties based on their knowledge of those properties from pictures. Given the steps involved in the pictorial induction task, it is perhaps not surprising that infants' understanding of the inductive potential of pictures is somewhat more fragile than the ability to extend words from pictures to objects. Specifically, to extend the nonobvious property of a depicted object to its referent, infants needed to form a representation of the depicted object, its nonobvious property, and of how to elicit this property from the picture book interaction. Infants then needed to access that representation when presented with the real object because the picture book was not available to infants at test. To elicit the nonobvious property on the real object, infants then needed to perform an action in the same way as this action was depicted in the book. Recall that the appearances of our objects offered no affordances. In contrast, to successfully transfer a novel word from a depicted object to a real-world object in the word learning tasks used in prior research (Ganea et al., 2008), children needed to recall one entity (the depicted object) rather than a number of entities (the depicted object, its nonobvious property, and the action used to elicit this property) and then use this information to point to or select the appropriate object when asked for it by name. Thus, both the complexity of the mental representation and the response required for successful performance on the current study's task may explain infants' tenuous performance.

In summary, the current findings advance our understanding of infants' inductive abilities, demonstrating that infants will make inductive inferences across symbolic modalities. That is, infants form expectations about nonobvious properties of objects after a brief picture book exposure that depicts those properties. This ability to transfer nonobvious properties from pictures to their real-world referents seems to be present as early as 13 months of age and continues to develop over the next few years of life.

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