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Do 9-Month-Old Infants Expect Distinct Words to Refer to Kinds?

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In 3 experiments, 9-month-old infants' expectations for what distinct count noun labels refer to were investigated. In Experiment 1, a box was opened to reveal 2 objects inside during familiarization: either 2 identical objects or 2 different objects. Test trials followed the same procedure, except before the box was opened, the contents were described using 2 distinct labels ("I see a wug! I see a dak!") or the same label twice ("I see a zav! I see a zav!"). Infants who heard a label repeated twice looked longer at 2 different objects versus 2 identical objects, whereas infants who heard 2 distinct labels showed a different pattern of looking. Experiments 2 and 3 presented infants with object pairs that only differed in shape or color, and it was found that infants expected the different-shaped (but not the different-colored) objects to be labeled by distinct count nouns. Because the property of shape is a cue to kind membership and the property of color is not, these results suggest that even at the beginning of word learning, infants may expect distinct labels to refer to distinct kinds of objects.

Keywords: sortal concepts, labeling, object representations

In everyday life, adults and children keep track of the kinds of objects they encounter and the individuals and individual objects they interact with. We categorize objects such as *dogs*, *chairs*, and *people*, and we have certain cognitive capacities to keep track of them over time and space: "Is this the same coffee mug that I left on my desk yesterday? I would not want to drink from someone else's mug! Is that my best friend Sally? Looks like she changed her hair and she is wearing contacts instead of glasses." Our perceptual and conceptual system cares a great deal about the number of objects in our mental model, the kinds of objects we represent, and how to keep track of the objects over time and space.

A subset of our concepts—namely, *sortal concepts*—refers to kinds and supplies the criteria for individuation (where one object ends and another one begins) and identity (whether an object is the same one as was seen on a different occasion; Gupta, 1980; Hirsch, 1982; Macnamara, 1986; Macnamara & Reyes, 1994; Wiggins, 1980; Xu, 1997; Xu & Carey, 1996). Sortal/kind information specifies categorization under concepts such as *dog*, *ball*, and *car*, categories of objects united by functional/causal features as well as by perceptual features. The sortal concept "dog," for example, provides criteria for deciding whether we see one or two dogs; it also provides criteria for deciding whether the dog we see now is the same dog encountered earlier or whether we have seen a different dog on each occasion.

To appreciate the conceptual role of sortals, consider two questions. First, how many are there? And second, is that the same as what was here before? It is impossible to answer either question without specifying a sortal—how many of *what*? One can count cups, desks, people, pages, or fingers, but one cannot count the blue, the sleeping, or the metal. Only sortals provide criteria of individuation. Similarly, "same" in the sense of numerical identity, indicates the *same one*, and a sortal is required to specify the individual being traced through time. Max the puppy grows to become an adult dog, changes size, coloring, shape, and location but is still the same dog. Max's identity is traced by the sortal *dog*.

Various studies have sought to determine when young children begin to represent sortal/kind concepts. Spelke, Kestenbaum, Simons, and Wein (1995) and Xu and Carey (1996) found that at both 4 and 10 months of age, infants are able to use spatiotemporal evidence for object individuation, thus demonstrating the ability to represent the sortal concept "physical object." In contrast, it is not until 10–12 months that infants are able to use basic-level sortal/kind information for object individuation (Bonatti, Frot, Zangl, & Mehler, 2002; Van de Walle, Carey, & Prevor, 2000; Wilcox & Baillargeon, 1998a [Experiments 1 and 2]; Xu & Carey, 1996; Xu, Carey, & Quint, 2004). More specifically, by 12 months of age, infants are able to use the differences between a duck and a ball, or a cup and a bottle, to establish a representation of two objects. In Xu and Carey (1996), infants were shown an event in which an object, a toy duck, emerged from behind a screen then returned behind it, followed by another object, a ball, emerging from behind the same screen then returning behind it. Adults draw on kind differences (ducks and balls are two different kinds of objects) to conclude that two distinct objects are involved in this event. The screen was then removed to reveal either both objects (the duck and the ball: the expected outcome) or just one of the two objects (the duck or the ball: the unexpected outcome). At 10 months, infants did not look longer at the unexpected outcome of a single

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object, suggesting that they did not use the kind differences between these objects to conclude that there were two distinct objects behind the screen. However, by 12 months of age, infants succeeded at this task, looking longer at the unexpected, single-object outcome. Xu and Carey (1996) hypothesized that 10-month-olds do not represent basic-level sortal/kind concepts such as *duck* and *ball*. Subsequently, using both looking time and manual search measures, Xu, Carey, and Welch (1999) and Van de Walle et al. (2000) provided convergent evidence for this shift between 10 and 12 months (see also Bonatti et al., 2002; Krojgaard, 2000; Wilcox & Baillargeon, 1998a [Experiments 1 and 2]).[1]

A recent study has provided evidence that 12-months-olds succeed at this object individuation task through the use of sortal/kind information as opposed to property or featural differences. Xu et al. (2004), using the paradigm of Xu and Carey (1996), conducted a series of experiments with 12-month-old infants to determine whether the ability to use the differences between a duck and a ball for object individuation is based on property differences (i.e., yellow, irregularly shaped, and rubbery vs. red, round, and shiny) or kind differences (i.e., a member of the kind *duck* vs. a member of the kind *ball*). They asked if infants would individuate objects on the basis of property differences alone—for example, color differences (a red ball vs. a green ball), size differences (a small red ball vs. a big red ball), or combinations of these properties (a small red ball vs. a big green ball). The results indicated that infants failed to use these property differences for object individuation. These findings suggest that certain salient shape differences enter into the computation of the numerical distinctness of objects before other property differences such as color and size. When within-kind shape differences (e.g., a regular cup vs. a sippy cup) were contrasted with cross-kind shape differences (e.g., a regular cup vs. a bottle), infants failed to use the within-kind shape differences for object individuation, whereas they succeeded in using cross-kind shape differences, even when the two types of shape differences were roughly equally salient to them. Since shape differences are often correlated with object kind differences, these results converge with previous findings suggesting that at 12 months, infants' represent some basic-level sortals/kinds, and it is sortal/kind distinctions that support object individuation. Thus, at 12 months of age, infants' success in a complex object individuation task may be based on object kind representations as opposed to property representations (see Xu, 2005, for a review).

Additional evidence from other laboratories also suggests that by the end of the 1st year of life, infants are able to distinguish property and kind information. Waxman and Markow (1995) and Waxman (1999) reported that by 13 months of age, the distinction between property and kind plays a role in infants' categorization. In these studies, infants were sensitive to whether they heard a count noun or an adjective while examining objects. If the children heard an adjective, they were more likely to generalize on the basis of a property, such as color or texture; however, if they heard a count noun, the infants were more likely to generalize to objects of the same kind on the basis of shape. These findings are consistent with the findings of Xu et al. (2004) that the distinction between kinds and properties is present by about 12–13 months and maps onto the linguistic distinction between count nouns and adjectives.

How do infants acquire sortal/kind concepts? Many have noted that infants begin to comprehend and produce their first words toward the end of the 1st year, and many of these first words are nouns for object categories (Bloom, 2000; Hall, 1993; Nelson, 1973). Recent studies provide evidence that language may play a causal role in this process (Balaban & Waxman, 1996; Waxman & Braun, 2005; Xu, 2002; Xu, Cote, & Baker, 2005).

Balaban and Waxman (1996) found that words, but not tones, facilitate categorization in 9-month-old infants. Infants were familiarized to pictures of a given category (e.g., *rabbits*). Some of the infants heard a word when shown a picture. For other infants, a tone accompanied the presentation of the picture. The findings indicate that although both the presentation of the words and the tones effectively heightened the infants' attention to the objects, it was only in the label condition that infants succeeded in categorizing the objects. When provided a label, it seems that infants group exemplars into a single category more readily than they do in the absence of a label. Waxman and Braun (2005) showed that only consistent labeling, not variable labeling, facilitated categorization in 12-month-old infants. A post hoc analysis from the study by Xu and Carey (1996) provides further suggestion that language may augment the acquisition of sortal/kind concepts. Although, as a whole, the 10-month-olds failed at the task of object individuation, those 10-month-olds with some linguistic knowledge of the objects were able to perform more like their 12-month-old counterparts. Perhaps having labels for objects is a means of establishing that they belong to different kinds.

To more directly examine the role of language in such a task, Xu (2002) presented 9-month-olds with the same object individuation task as was used in Xu and Carey (1996), with one crucial manipulation: As each object emerged from behind the screen, the infants heard a label for the object in infant-directed speech (e.g., "Look, a duck!" or "Look, a ball!"). In the one-label condition, the infants heard a single label applied to both objects (e.g., "Look, a toy"). In the two-label condition, but not in the one-label condition, infants looked longer at the unexpected outcome. Thus, upon hearing two contrastive labels when seeing the emerging objects, even 9-month-old infants were able to use the differences in object kind to establish a representation of two distinct objects. In addition, 9-month-olds succeeded on this task when a pair of unfamiliar objects labeled with nonsense words (e.g., "a fendle" or "a toma") was used. The fact that familiarity with the objects and the labels was not necessary to succeed at this task suggests that it is the presence of distinct labels, per se, that allows infants to establish a representation of two distinct individual objects.

Are these facilitation effects language specific? Would other types of auditory information be equally helpful for this individuation task? Subsequent experiments in Xu (2002) used two tones, two distinct sounds, or two emotional expressions instead of two

[1] There is evidence to suggest that infants younger than 12 months of age are able to use property information for establishing the representation of two distinct objects when task demands are reduced. For example, Wilcox and Baillargeon (1998a [Experiments 7 and 8], 1998b, Wilcox & Schweinle, 2002), using a simplified object individuation procedure, showed that 9-month-olds or even younger infants were able to use featural information to individuate objects. Xu and Baker (2005), using a simplified manual search measure, demonstrated this ability in 10-month-olds. The present discussion focuses on when infants' begin to use sortal/kind information for object individuation, which is a related but distinct question from when they begin to use property information for this purpose (see Xu, 2005, for a review).

words. Nine-month-olds did not look longer at the one-object, unexpected outcome during the test trials when tones, sounds, or emotional expressions were used. These findings suggest that infants are able to use distinct labels to help them to succeed earlier (i.e., at 9 months as opposed to 12 months) in a task of object individuation, and these facilitation effects appear to be language specific.

How powerful are words in guiding object individuation? Xu et al. (2005), using a manual search procedure, asked if 12-month-old infants could use labeling to establish object representations even when the objects were never shown to them. On a two-word trial, an experimenter looked into the opening of a box and referred to what was inside (e.g., "Look, a fep!" and "Look, a wug!"). On a one-word trial, the experimenter looked into the box and used the same word twice (e.g., "Look, a zav!"). Infants spontaneously reached into the box and always retrieved one object. The box was then empty and sat within reach of the infant. If they had heard two distinct labels, an adult would reach in a second time to look for another object but would not reach in again if he or she had heard only a single label. Twelve-month-old infants behaved similarly. Even without having seen the objects beforehand, the act of referring led the 12-month-olds to posit objects inside the box, and the number of distinct labels appeared to inform the infants of the number of objects to be expected inside the box. In addition, this effect seems to be specific to linguistic expressions since the number of emotional expressions did not help infants establish the number of objects inside the box. Thus, labeling, when presented with abundant intentional and referential cues, can guide the process of establishing the number of distinct objects involved in an event for infants as young as 12 months of age.

One empirical question remains unanswered from the results of Xu (2002) and Xu et al. (2005): Did the infants in this study interpret the distinct words as referring to distinct kinds of objects (types) or distinct individual objects (tokens)? Studies investigating the facilitating effect of language on object individuation (Xu, 2002; Xu et al., 2005) provide evidence that the use of two distinct labels leads infants to posit two objects involved in the event, but what cannot be determined from the empirical evidence to date is whether infants expect there to be merely two individual objects present or whether the objects involved must be of two different kinds. For adults and older children, distinct words (in the form of count nouns) tend to refer to distinct kinds of objects. Further empirical evidence is required to establish that the presence of two distinct labels leads infants to expect two different kinds of objects.

The current study sought to address this question directly by examining the effect of labeling on 9-month-old infants' expectations regarding the nature of named objects. Since previous studies have established that providing two labels leads 9-month-olds to expect two objects to be involved in an event, in the current study, we focused on infants' specific expectations about the two objects themselves. Instead of asking infants to decide how many objects there were in an event, the current study always presented two objects, and what was manipulated was the degree of difference between the two objects. Infants were asked to use labeling information as a cue to predict which of the two-object outcomes would be revealed.

In the first experiment, infants watched events presented on a puppet stage. During the familiarization trials, a box was opened to reveal two objects inside. The revealed objects were either two identical objects or two different objects. The test trials followed the same procedure, and used the same objects, as familiarization trials except that before the box was opened, the experimenter looked into the top of the box and described its contents using two distinct object labels (e.g., "I see a wug!" and "I see a dak!") or the same label twice (e.g., "I see a zav!" and "I see a zav!"). The experimenter looked intently into the box during labeling, providing abundant intentional and referential cues, as in Xu et al. (2005). The box was then opened to reveal the object-pair outcome (either two identical objects or two different objects). The question of interest was whether the number of distinct labels would help infants determine the nature of objects inside the box. If infants expect that distinct labels refer to distinct kinds of objects, when two distinct labels are used to refer to unseen objects inside a box, they should look longer when shown two identical objects inside. However, if infants expect only that distinct labels refer to distinct individual objects, when two distinct labels are used, they should look equally long whether two identical objects or two different objects are revealed because, in both outcomes, two distinct individual objects are present.

In a second experiment, using the same procedure, infants were presented with either identical pairs of objects or pairs of objects that were the same in every property but shape. The property of shape is a very salient cue to kind membership (Landau, Smith, & Jones, 1988; Soja, Carey, & Spelke, 1991). Infants may expect that objects that differ in shape should have different labels. However, if different objects differ along a property dimension not linked to kind membership, infants may show a different looking pattern. This possibility was examined in a third experiment, in which objects pairs were either identical or differed only in color. The current set of experiments addressed the question of whether infants, at the beginning of word learning, expect distinct words to refer to distinct kinds of objects.

Experiment 1

Method

Participants. Participants were 24 full-term infants (12 male, 12 female; mean age = 9 months, 0 days; range = 8 months, 8 days, to 9 months, 15 days). All infants were recruited from the greater Vancouver (British Columbia, Canada) area by mail and subsequent phone calls. Most infants came from a middle-class, non-Hispanic White background, with 21% of infants Asian, 4% African Canadian, and 4% Hispanic. The infants received a token gift (a T-shirt or bib with a university logo) after the study. English was the primary language spoken at home for all infants. An additional 4 infants were tested but excluded due to fussiness (3) or parental interference (1).

Materials. Objects were presented in a 28 × 19 × 23-cm box constructed out of foam core. The top of the box had an opening that measured 18 × 10 cm and was covered by spandex. The front of the box swung open in a doorlike movement. Four pairs of objects were used in the study: a toy frog (approximately 8 × 14 cm in size) and a plush toy lion (approximately 14 × 8 cm in size), a plush toy dog (approximately 10 × 12 cm in size) and a plush bird (approximately 9 × 12 cm in size), a toy train (approximately 9 × 6 cm in size) and a star-shaped puzzle (approximately 10 × 10 cm in size), and a double pinwheel (approximately 9 × 17 cm

in size) and a ball figure (approximately 8 × 15 cm in size). Each of the eight objects had a duplicate. Each object sat atop a square of white foamcore with a magnet on the bottom so that the objects could be spaced a uniform distance apart (see Figure 1 for an example of the identical and different object outcomes).

Apparatus. The events were presented on a stage with a display area that measured 94 cm in width and 55 cm in height. The infant sat in a high chair about 30 cm from the stage, with eye level slightly above the floor of the stage (about 8 cm). The parent sat next to the infant with his or her back toward the stage. A video camera, set up under the stage, focused on the infant's face and recorded the entire session. The video camera was connected to a 19-in (48.26-cm) TV placed in one corner of the room. An observer watched the infant on the TV monitor and recorded the infant's looking times. The observer was not able to see what was presented on the stage, nor was she aware of the order of the trials. A key on a laptop computer was pressed during infants' on-target looking. A computer program written specifically for looking time studies (Hypercard [Version 2.4.1]; Pinto, 1995) was used to record the looking times.

Design and procedure. The experimenter began by waving a set of keys at all corners of the stage to define the window of looking for the observer. During the experiment, the experimenter sat behind the stage in view of the infant at all times.

To begin, the experimenter looked into the top of the empty box, pulling apart the spandex covering so as to look inside. The front door of the box was opened to show the infant that the box was empty. In infant-directed speech, the experimenter said, "Look, it's empty! There's nothing in there!" The door of the box was then closed and the box turned around. The familiarizations trials were then started.

Familiarization trials. Each infant received eight familiarization trials. Two objects were placed inside the box, out of view of the infant. The box was then turned to face the infant. The experimenter pulled apart the spandex on top of the box, so she was looking at the objects inside the box. While looking inside, the experimenter said, "I see something! There's something there! [Infant's name], look!" The front door of the box was then opened to reveal the objects inside. The experimenter lowered her head and eye gaze to ensure that she was not making eye contact with the infant while the box contents were visible. Infant looking times were recorded. When the infant turned away for 2 consecutive seconds, the trial ended. The door of the box was closed, and the box was turned around so that the door of the box was facing the

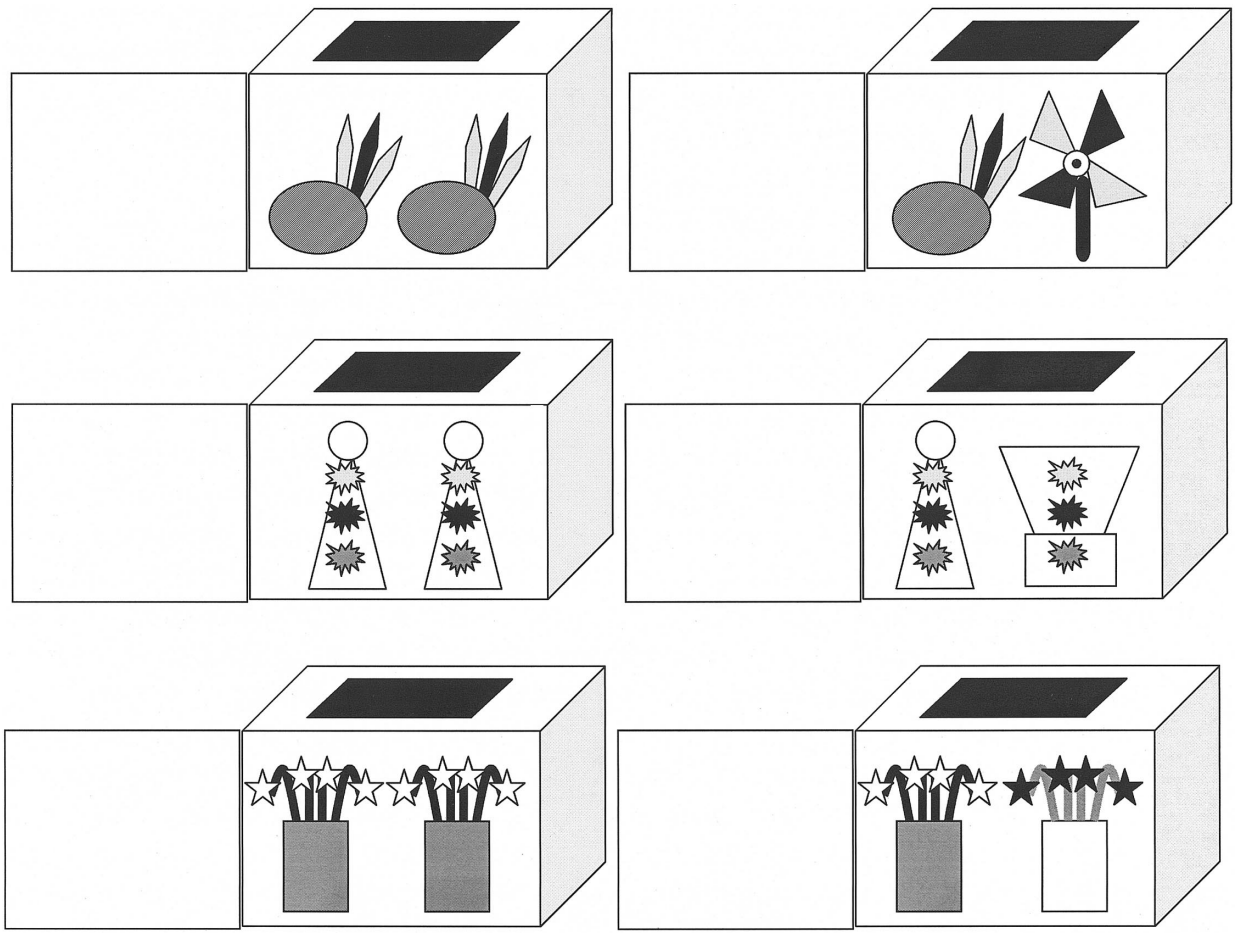

Figure 1. Examples of identical and different (or different-shaped, or different-colored) object outcomes from Experiments 1–3.

experimenter and the infant was facing the back of the box. New objects were placed inside the box to begin the next trial. Objects from each of the four pairs (frog–lion, dog–bird, train–puzzle, ball–pinwheel) were shown during the familiarization trials (either both objects of the pair were shown [different objects], or one object from the pair was shown with its duplicate [identical objects]). Familiarization Trials 5–8 were a repetition of Trials 1–4. Which objects were shown, which side of the box an object was positioned on, and the order of object pairs were counterbalanced across infants.

Test trials. Test trials followed an identical procedure to that of the familiarization trials, with one critical difference: Before opening the front of the box, the experimenter looked into the top of the box and labeled the objects inside with either the same label two times (e.g., "I see a zav! I see a zav! There's a zav! There's a zav! [Infant's name], a zav! [Infant's name], a zav!") or with two different labels (e.g., "I see a wug! I see a dak! There's a wug! There's a dak! [Infant's name], a wug! [Infant's name], a dak!"). Each sentence was spoken in infant-directed speech as the experimenter looked into the box. Each infant was shown four test trials. Infants were shown two label/object combinations for both the expected and unexpected outcomes. For an expected outcome, an infant either heard two different labels applied to the objects inside the box and two different objects were revealed when the box was opened, or, conversely, an infant heard one repeated label applied to the objects inside the box and two identical objects were revealed when the box is opened. For an unexpected outcome, an infant either heard two different labels applied to the objects inside the box and two identical objects were revealed when the box was opened, or, conversely, an infant heard one repeated label applied to the objects inside the box and two different objects were revealed when the box was opened. The 8 objects were labeled with nonsense words ("fep," "zav," "wug," "dak," "toma," "blicket," "muba," and "tupple"). Throughout the study, a particular object was always labeled with the same nonsense word; thus, each object pair was always labeled with the same label pair. The same objects from each of the four pairs (frog–lion, dog–bird, train–puzzle, ball–pinwheel) that were shown during the familiarization trials were shown on the test trials, but the order of object presentation differed from that of the familiarization trials. The four test trials included two instances of expected and unexpected outcomes such that all four of the Label × Object Pair outcomes were shown (repeated label/identical objects [expected], different labels/different objects [expected], repeated label/different objects [unexpected], different labels/identical objects [unexpected]). The order of outcome (whether the infant saw an expected or unexpected trial first, whether an identical or different object outcome was presented first, or whether objects were first labeled with repeated or different labels) was counterbalanced across infants (see Figure 2 for a schematic representation of the experimental procedure).

To evaluate whether any unintentional variations in the experimenter's actions or utterances during the test trials could have biased infants' responses, a coder blind to the order of object-pair outcome reviewed the test trials for each infant and guessed the object outcome for each trial on the basis of the experimenter's labeling and referential behavior. The coder was able to guess the object-pair outcome (identical or different) on only 50% of the test trials (48 out of 96 trials), which is not different from chance.

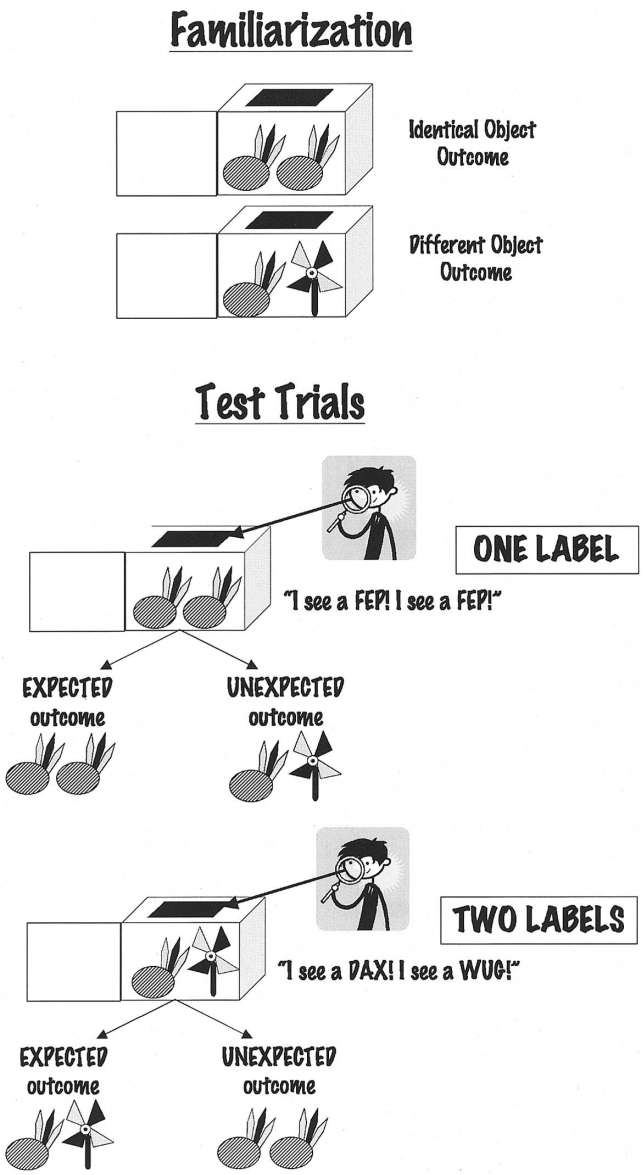

Figure 2. A schematic representation of the experimental procedure for Experiment 1.

Results

The results of Experiment 1 are shown in Figure 3. An alpha level of .05 was used in all statistical analyses. Preliminary analyses found no effects of gender, test trial order (whether the expected or unexpected trial was presented first), or animacy (animate vs. inanimate) of the object pairs. Subsequent analyses were collapsed over these variables. All infants were offline observed by a second observer who was completely blind to the order of object outcome. Interscorer reliability averaged 96%.

Familiarization trials. Averaging across all eight of the familiarizations trials, it was found that infants looked slightly longer when two different objects were revealed ($M_{\text{different}}$ = 14.04 s, SD = 6.03) than when two identical objects were revealed ($M_{\text{identical}}$ =

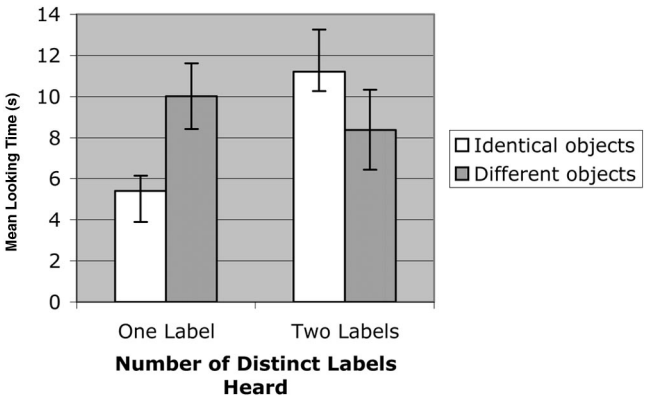

Figure 3. Mean looking times as a function of the number of distinct labels heard and the revealed object-pair outcome for Experiment 1.

12.61 s, $SD = 4.91$); however, this difference was not statistically significant, $t(23) = -1.14$, $p = .27$.

Test trials. Infants' looking times to the test outcomes were compared by means of a 2×2 repeated measures analysis of variance (ANOVA), with number of labels (one vs. two) and object-pair outcome (identical vs. different) as within-subject factors. The analysis revealed a significant interaction, $F(1, 23) = 5.06$, $p = .03$, effect size (η_p^2) = .18. We performed planned comparisons for each label number (one repeated label vs. two different labels) to determine whether infants looked longer to one of the two object outcomes (either identical objects or different objects). When infants heard the box contents described using one label repeated twice, they looked significantly longer when two different objects were revealed (the unexpected outcome; $M = 10.02$ s, $SD = 7.86$) than when two identical objects were revealed (the expected outcome; $M = 5.41$ s, $SD = 3.57$), $t(23) = -2.93$, $p < .01$. When infants heard the box contents described using two distinct labels, they looked longer when two identical objects were revealed (the unexpected outcome; $M = 11.20$ s, $SD = 10.04$) than when two different objects were revealed ($M = 8.38$ s, $SD = 9.53$), although this difference was not significant, $t(23) = 1.13$, $p = .27$. Examination of individual infants' patterns of looking, by means of nonparametric analyses, yielded similar results between these conditions. When one repeated label was applied to the box contents, 16 of 24 infants looked longer when two different objects were revealed (unexpected outcome) than when two identical objects were revealed (expected outcome; Wilcoxon signed ranks test: $z = -2.23$, $p = .01$ [one-tailed]). Conversely, when two distinct labels were applied to the box contents, 16 of the 24 infants looked longer when two identical objects were revealed (unexpected outcome) than when two different objects were revealed (expected outcome; Wilcoxon signed-ranks test: $z = -1.66$, $p < .05$ [one-tailed]). The use of one-tailed tests for the nonparametric analysis was justified because we had clear predictions for the infant looking patterns. When one repeated label was heard, we expected infants would be surprised to see two different objects revealed but not surprised to see two identical objects. The opposite was true when two different labels were heard.

Discussion

When infants hear one repeated label, they expect the duplicated label to refer to identical objects. Conversely, a trend in the present looking data suggests that when infants hear two distinct labels, they seem to expect those labels to refer to distinct objects. Note that the latter effect seemed weaker (i.e., the *t* test was not, by itself, statistically significant). A possible reason why infants might not have seemed quite as surprised to see two identical objects after hearing two distinct labels is that this looking pattern required infants to overcome their slight baseline preference for the different-object outcome. Thus, for infants to look longer at the identical object pair (the unexpected outcome) after hearing two distinct labels, they had to overcome this preference. It is not the case, however, that infants simply preferred to look longer at the different-object outcome in general, because there was no main effect of object outcome.

Up until now, studies investigating the facilitating effect of language on object individuation (i.e., Xu, 2002; Xu et al., 2005) have provided evidence that the use of two distinct labels leads infants to posit two objects involved in an event. The results of Experiment 1 indicate that infants may not only expect two distinct labels to refer to two individual objects; a trend in the looking data suggests that infants may expect those individual objects to be different.

What remains to be demonstrated is whether the infants expect these different objects to vary from each other in a specific fashion. In other words, must the two objects simply be dissimilar to each other in some respect, or is the way in which the objects differ important? We use distinct words to designate different kinds of things (i.e., objects within a kind share the same label). And, in general, objects that vary along a property dimension that does not affect kind membership are not marked by different basic-level labels. When we consider various perceptual dimensions of objects, some are better correlated with kind membership than others. The property shape is closely connected with kind membership (Landau et al., 1988; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Soja et al., 1991). Broadly speaking, objects that differ in shape are usually different kinds of things and are marked by different basic-level count noun labels (Samuelson & Smith, 2005). In contrast, the property of color is not closely connected with kind membership and it is not usually marked by different basic-level count nouns.

If infants expect two distinct labels to mark two different kinds of objects, they will look longer at the unexpected outcomes if the property difference between the objects implies a difference in kind (e.g., shape), but infants will not look longer at the unexpected outcomes if the property difference between the objects does not imply a difference in kind membership (e.g., color). In Experiments 2 and 3, we used the same procedure as Experiment 1, except that the different object pairs differed only in shape or color, respectively.

Experiment 2

Method

Participants. Participants were 16 full-term infants (8 male, 8 female; (mean age = 9 months, 2 days; range = 8 months, 15 days, to 9 months, 13 days). All infants were recruited from the

same population as in Experiment 1, but none had participated in the first experiment. Most infants came from a middle-class, non-Hispanic White background, with about 13% of infants Asian and 6% Hispanic. English was the primary language spoken at home for all infants. An additional 5 infants were tested but excluded due to fussiness (4) or parental interference (1).

Materials and apparatus. All materials and apparatus were the same as those used in Experiment 1 except for the objects presented to the infants. Four pairs of objects were used in this experiment. The objects in each pair were identical in material, texture, and color; thus, the objects in each pair differed from one another only in shape. Every object had a duplicate (see Figure 1).

Design and procedure. These were identical to those of Experiment 1. A coder blind to the order of object-pair outcome reviewed the test trials for each infant and guessed the object outcome for each trial on the basis of the experimenter's labeling and referential behavior. The coder was able to guess the object-pair outcome (identical or different) on only 44% of the test trials (28 out of 64 trials), which is not different from chance.

Results

The main results of Experiment 2 are shown in Figure 4. Preliminary analyses found no effects of gender, test trial order (whether the expected or unexpected trial was presented first), or animacy (animate vs. inanimate) of the object pairs. Subsequent analyses were collapsed over these variables. Half of the infants were randomly selected and offline observed by a second observer who was completely blind to the order of object outcome. Inter-scorer reliability averaged 97%.

Familiarization trials. Averaging across all eight of the familiarizations trials, it was found that infants looked equally long whether two different-shaped objects were revealed ($M_{\text{different}}$ = 12.52 s, SD = 3.42) or two identical objects were revealed ($M_{\text{identical}}$ = 12.93 s, SD = 3.75), $t(15) = .44$, $p = .66$.

Test trials. Infants' looking times to the test outcomes were compared by means of a 2 × 2 repeated measures ANOVA, with number of labels (one vs. two) and object-pair outcome (identical vs. different) as with-subject factors. The analysis revealed a significant interaction, $F(1, 15) = 8.16$, $p = .01$, effect size (η_p^2) = .35. Planned comparisons were performed. When infants heard the box contents described using a single label repeated twice, they looked significantly longer when two different objects were revealed (the unexpected outcome; M = 10.34 s, SD = 6.06) than when two identical objects were revealed (the expected outcome; M = 6.89 s, SD = 3.41), $t(15) = -2.14$, $p = .05$. When infants heard the box contents described using two distinct labels, they looked longer when two identical objects were revealed (the unexpected outcome; (M = 10.04 s, SD = 8.84) than when two different objects were revealed (M = 5.72 s, SD = 3.72), although this difference was only marginally significant, $t(15) = 2.03$, $p = .06$. Examination of individual infants' patterns of looking, by means of nonparametric analyses, provided similar results. When one repeated label was applied to the box contents, 12 of 16 infants looked longer when two different objects were revealed (unexpected outcome) than when two identical objects were revealed (expected outcome; Wilcoxon signed-ranks test: $z = -1.86$, $p = .03$ [one-tailed]). Conversely, when two distinct labels were applied to the box contents, 9 of the 16 infants looked longer when two identical objects were revealed (unexpected outcome) than when two different objects were revealed (expected outcome; Wilcoxon signed-ranks test: $z = -1.55$, $p = .06$ [one-tailed]).

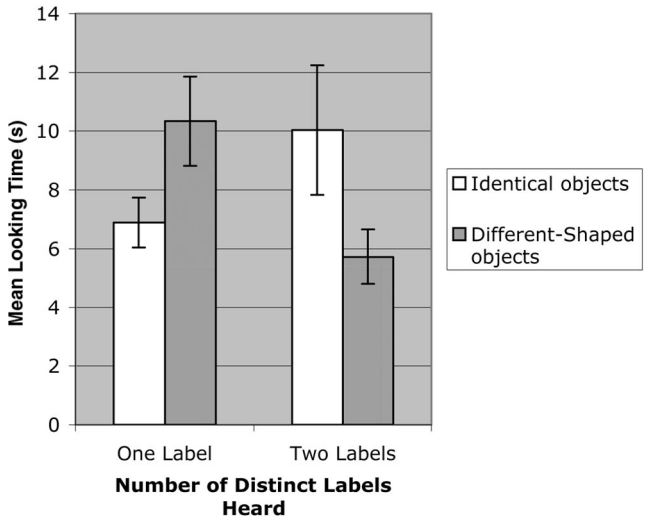

Figure 4. Mean looking times as a function of the number of distinct labels heard and the revealed object-pair outcome for Experiment 2.

Discussion

In this experiment, the only dissimilarity between the different object pairs was the property of shape. Therefore, the different-shaped object pairs shared many more features than the different object pairs of the first experiment. In Experiment 1, the different object pairs differed maximally along all property dimensions. Yet the results of the current experiment mirror those of the previous experiment. Thus, it seems that for 9-month-old infants, objects that differ in shape, like objects that differ completely, are expected to be marked by distinct labels.

It could be the case, however, that infants expect that objects that differ along *any* perceptual dimension should be marked by distinct labels. Perhaps the infants displayed looking time patterns similar to those in the first experiment when shown object-pair outcomes that alternated between identical objects and objects that differed in shape not because shape is closely tied to kind membership but because any perceived difference between the different object pair would have produced this effect. This possibility was explored in Experiment 3, in which the different object pairs differed only in color. For the kinds of objects we used in this study, color is a property difference that does not correlate with kind membership.

Experiment 3

Method

Participants. Participants were 16 full-term infants (8 male, 8 female; mean age = 9 months, 0 days; range = 8 months, 15 days, to 9 months, 14 days). All infants were recruited from the same population as in Experiment 1, but none had participated in Experiments 1 or 2. Most infants came from a middle-class, non-

Hispanic White background, with about 12% of infants being Asian. English was the primary language spoken at home for all infants. An additional 6 infants were tested but excluded due to fussiness (5) or parental interference (1).

Materials and apparatus. All materials and apparatus were the same as those used in Experiment 2 except for the objects presented to the infants. Four pairs of objects were used in this experiment. The objects used in this experiment were almost identical to the objects used in Experiment 2. Each object used in Experiment 2 was duplicated, but every color of the original object was changed, resulting in an identical pair that differed only in color. Every object used in this experiment also had a duplicate (see Figure 1).

Design and procedure. These were identical to those of Experiments 1 and 2. A coder blind to the order of object-pair outcome reviewed the test trials for each infant and guessed the object outcome for each trial on the basis of the experimenter's labeling and referential behavior. The coder was able to guess the object-pair outcome (identical or different) on only 50% of the test trials (32 out of 64 trials), which is not different from chance.

Results

The main results of Experiment 3 are shown in Figure 5. Preliminary analyses found no effects of gender, test trial order (whether the expected or unexpected trial was presented first), or animacy (animate vs. inanimate) of the object pairs. Subsequent analyses were collapsed over these variables. Half of the infants were randomly selected and offline observed by a second observer who was completely blind to the order of object outcome. Interscorer reliability was 97%.

Familiarization trials. Averaging across all eight of the familiarization trials, it was found that infants looked equally long whether two different-colored objects were revealed ($M_{\text{different}}$ = 9.68 s, SD = 4.11) or two identical objects were revealed ($M_{\text{identical}}$ = 11.24 s, SD = 7.11), $t(15) = .92$, $p = .37$.

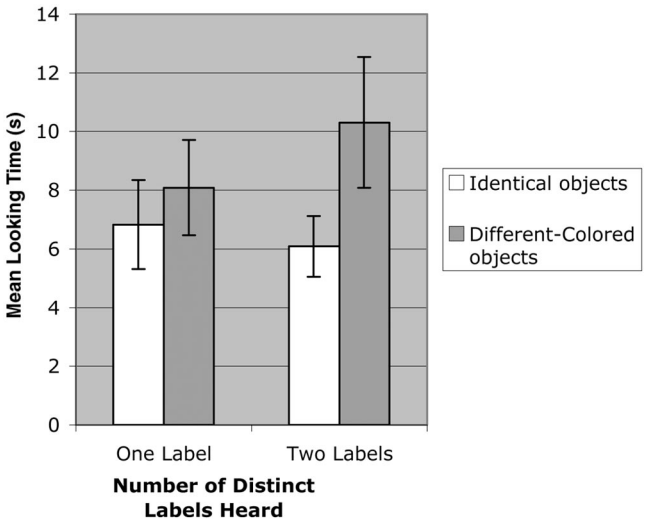

Figure 5. Mean looking times as a function of the number of distinct labels heard and the revealed object-pair outcome for Experiment 3.

Test trials. Infants' looking times to the four test outcomes were averaged and compared by means of a 2 × 2 repeated measures ANOVA, with number of labels (one vs. two) and object-pair outcome (identical vs. different) as with-subject factors. The analysis revealed a significant main effect of object-pair outcome, $F(1, 15) = 7.61$, $p = .02$, effect size (η_p^2) = .34. Thus, collapsing over number of labels heard, infants looked longer when different-colored objects were revealed ($M_{\text{different}}$ = 9.20 s, SD = 6.24) than when two identical objects were revealed ($M_{\text{identical}}$ = 6.46 s, SD = 4.22). More important, there was no interaction between the number of labels and object-pair outcome, $F(1, 15) = 1.88$, $p = .19$.

The data from Experiments 1, 2, and 3 were combined and infants' looking times to the test outcomes were compared by means of a 3 × 2 × 2 repeated measures ANOVA, with experiment (1, 2, or 3) as the between-subjects factor and number of labels (one vs. two) and object-pair outcome (identical vs. different) as within-subject factors. The analysis revealed a significant three-way interaction, $F(1, 53) = 3.77$, $p = .03$, effect size (η_p^2) = .13. Thus, infants' patterns of looking to each of the test outcomes differed between Experiments 1, 2, and 3.

Comparing infants in Experiments 1 and 2, no Experiment × Number of Labels × Object-Pair Outcome interaction was found, $F(1, 38) = .005$, $p = .94$. Thus, infants' pattern of looking to each of the test outcomes did not differ between Experiments 1 and 2. However, a significant two-way interaction was found between number of labels and object-pair outcome, $F(1, 38) = 10.81$, $p < .01$, effect size (η_p^2) = .22. Planned comparisons were performed. When infants heard the box contents described using one label repeated twice, they looked significantly longer when two different (either completely different or different in shape) objects were revealed (the unexpected outcome; M = 10.15 s, SD = 7.11) than when two identical objects were revealed (the expected outcome; M = 6.00 s, SD = 3.54), $t(39) = -3.66$, $p < .01$. When infants heard the box contents described using two distinct labels, they looked longer when two identical objects were revealed (the unexpected outcome; M = 10.73 s, SD = 9.48) than when two different (either completely different or different in shape) objects were revealed (M = 7.31 s, SD = 7.79), $t(39) = 2.00$, $p = .05$.

Comparing infants in Experiments 1 and 3 only, a significant Experiment × Number of Labels × Object-Pair Outcome interaction was found, $F(1, 38) = 5.52$, $p = .02$. Therefore, infants' patterns of looking to each of the test outcomes differed between Experiment 1 and Experiment 3. Furthermore, comparison of only those infants in Experiments 2 and 3 revealed a similar finding; the Experiment × Number of Labels × Object-Pair Outcome interaction was significant, $F(1, 30) = 9.55$, $p < .01$. Thus, infants' patterns of looking to each of the test outcomes did differ significantly between Experiment 2 and Experiment 3. Because the looking time patterns for infants in Experiments 1 and 2 are statistically equivalent, it can be said that the looking patterns obtained in Experiment 3 are different from those obtained in Experiments 1 and 2.

Discussion

The results of Experiment 3 differed from those of both Experiments 1 and 2. Infants did not expect two distinct labels to refer to two different-colored objects. The number of labels used did not

have an effect on which object-pair outcome the infants expected to see inside the box. Therefore, it appears that not just any perceptual dissimilarity between different object pairs is sufficient for infants to expect that they should be marked by distinct labels. Moreover, it seems that infants expect that only objects that differ in kind-relevant features (i.e., shape) should be marked by distinct labels.

How do we interpret the looking time pattern in Experiment 3? In the previous two experiments, the object outcomes alternated between identical objects and different kinds of objects. Thus, labeling was a cue to object outcome: Hearing distinct labels led to the expectation of seeing two kinds of objects (different[-shaped] object outcome), whereas hearing one repeated label led to the expectation of seeing one kind of object (identical object outcome). However, in this experiment, when infants were shown, during familiarization, that the object outcomes alternated between identical and different-colored objects, both outcomes involved only one kind of object. Thus, if infants expect labels to pick out kinds, then the labeling in Experiment 3 was uninformative, because both object outcomes involved only one kind of object. In this case, the labeling was not predictive of object outcome, and therefore, it may have been ignored.

General Discussion

After seeing the contents of a box alternate between either two identical objects or two different objects (Experiment 1), 9-month-old infants who subsequently heard the hidden contents of the box referred to using one repeated label looked reliably longer when the box was opened to reveal two different objects inside. Conversely, on hearing the hidden contents referred to using two distinct labels, infants did not show a reliable preference for one outcome over the other and, if anything, showed a nonsignificant preference for the test event with two identical objects. A stronger pattern of results was obtained when infants were shown that the box contents alternated between either two identical objects or two objects that differed only in shape (Experiment 2). Here again, infants who heard the contents of the box referred to using two identical labels looked longer when the box was opened to reveal two different-shaped objects. In contrast, when two distinct labels were used to label the hidden contents, infants in this experiment looked significantly longer when two identical objects were revealed. For infants watching these events, labeling acts as a cue to object-pair outcome. Under these circumstances, when infants hear one repeated label used to describe the (unseen) box contents, they expect that the box will open to reveal two identical objects, and when they hear the contents described using two distinct labels, they expect to see two different-shaped objects inside the box (Experiment 2). However, these expectations are not upheld when infants are first shown that the box contents alternate between either two identical objects or two different-colored objects (Experiment 3). In this case, infants simply look longer when the box is opened to reveal two different-colored objects, independent of the number of labels heard. Here, labeling does not appear to add any predictive cues as to what infants can expect to see when the box is opened.

An empirical question that remained unanswered from the results of previous studies examining the effect of labeling on infants' object representations (Xu, 2002; Xu et al., 2005) was whether the infants in these studies interpreted the distinct words as referring to distinct kinds of objects (types) or distinct individual objects (tokens). The current set of experiments provides evidence that even young infants expect distinct words to refer to kinds. In these experiments, the object-pair outcomes alternated between two identical objects or two objects that differed in some respect. If it were the case that infants merely expect distinct words to refer to individual objects, then when infants hear two distinct labels, they should look equally at two identical objects as they do at two different objects, because both outcomes represent two individual objects. However, the results of the current study suggest that this is not the case. Furthermore, it is not enough to say that infants expect distinct words to refer to different objects: It is evident from these results that the ways in which the different objects differ is important. The property of shape is a very salient cue to kind membership (Landau et al., 1988; Rosch et al., 1976; Soja et al., 1991), and it was hypothesized that infants may expect that objects that differ in shape should have different labels. The results of the second experiment (identical objects vs. different-shaped objects) lend support to the idea that, even for young infants, objects that differ in shape are seen as different kinds of things. Here, infants expected two different-shaped objects to be labeled with two distinct count nouns. In both of the first two experiments, the two object-pair outcomes alternated between one kind (identical objects) and two kinds (different[-shaped] objects). Our results show that labeling can be used to distinguish between these two object outcomes. However, if the different objects varied along a property dimension not linked to kind membership (in this case, color), it was hypothesized that infants might show a different looking pattern. This prediction was confirmed in the third experiment (identical objects vs. different-colored objects). Here, infants did not use labeling information to help them predict object-pair outcome. We suggest that the reason that labeling does not assist infants when the objects are either identical or different-colored is because both object-pair outcomes represent only one kind of object. Because distinct labels are used to mark distinct kinds, if the box contents do not alternate between same and different kinds, the labeling information cannot be used to predict object-pair outcome. It is clear from the results of this series of experiments that infants are sensitive to perceptual dimensions that are related (or unrelated) to kind membership.

It should be made clear that there is no evidence that the 9-month-olds in the current study actually learned the labels for the objects, nor were they expected to. The events presented to the infants involved both novel objects and novel labels. In addition, the labels were only presented when the objects were not visible (i.e., when the box was closed). These certainly are not optimal conditions for word learning, especially for infants of this age. However, even in the absence of specific word–object mappings, infants as young as 9 months seem to expect distinct words to refer to different sortal concepts, which in turn map onto different kinds of objects in the world.

Other research in the literature provides convergent evidence that infants expect words to pick out sortal kinds (Xu, 2005, in press). For example, Balaban and Waxman (1996) and Waxman and Braun (2005) found that consistent labels, but not tones or variable labels, facilitate categorization in 9-month-old infants, suggesting that when provided a label, infants group exemplars into a single category more readily than they do in the absence of

a label. In addition, if two kinds of objects are inferred in an event because two distinct labels are heard, there must be two distinct tokens of objects present, as in the object-individuation task (e.g., Xu, 2002). Moreover, objects that share a label and, thus, are the same kind of thing should share certain nonobvious properties, as in an inductive inference task. For example, at 13 and 18 months, when objects share a common label, infants are more likely to produce a nonobvious property (e.g., squeeze it to make a sound; Graham, Kilbreath, & Welder, 2004; Joshi & Xu, 2007; Welder & Graham, 2001). The current study is consistent with these lines of research as it indicates that when 9-month-old infants hear a repeated label, they expect the referents of that label to be identical (i.e., the same kind of thing), but when they hear two distinct labels, they expect the referents of those labels to be different in kind.

The labels used in these experiments were all presented in a count noun frame. It remains an open question whether the expectation that words refer to sortal kinds is specific to count nouns. It is not clear whether 9-month-old infants have made a syntactic distinction between count nouns and adjectives, so it would not be easy to address the question at this young age. By 13 months, however, some evidence suggests that infants have learned that count nouns correlate with objects that share a common shape, whereas adjectives tend to correlate with properties such as color or texture (Waxman, 1999). Word-learning studies with older infants have demonstrated that infants' sensitivity to object category (kind) and object property (color) is influenced by the grammatical form class of the novel label. Booth and Waxman (2003) found that 14-month-olds' construal of objects is influenced by naming. They found that infants extended novel nouns ("This one is a blicket") specifically to object categories (e.g., *animal*) and not to object properties (e.g., purple things). Conversely, infants extended novel adjectives ("This one is blickish") to object properties when the property was color. The results of the current study demonstrate that when novel count nouns are presented, 9-month-olds expect distinct count nouns to correspond to a category-relevant commonality among the objects (shape) but not to a property-based commonality (color).

Do young children understand that shape is a salient cue to kind membership, or have they simply formed an association between labeling and shape such that objects that are referred to by the same label share the same shape and objects that are marked by distinct labels have different shapes? It has been suggested that young children demonstrate a "shape bias" in word learning such that objects that share the same shape should also share a label (i.e., Landau et al., 1988; Smith, Jones, Landau, Gershkoff-Stowe, and Samuelson, 2002). However, other studies examining preschoolers' naming of pictorial representations strongly suggest that children do not always apply labels on the basis of shape alone (Bloom & Markson, 1998; Gelman & Ebeling, 1998). If shape alone does not determine labeling, perhaps shape may simply be a proxy for kind membership. With 9-month-old infants, however, we do not yet have evidence of whether shape functions as a proxy for kind membership or whether words simply pick out groups of objects that have distinct shapes.

Although the current study did not require infants to learn the specific mappings between words and objects, it nevertheless offers insight into the nature of infants' representation of early words in two ways. First, many word-learning studies with young children have shown that children pay close attention to the intentional act of referring and that factors such as joint attention and speaker's gaze play a critical role in how children decide which object is the referent of a new word (e.g., Baldwin, 1991, 1993; Bloom, 2000; Tomasello, Strosberg, & Akhtar, 1996). It has been previously shown that infants as young as 12 months of age are able to use labeling to generate object representations even when the objects are never shown to them (Xu et al., 2005). The results of the current study provide indirect evidence that even younger infants are able to use intentional and referential cues (i.e., speaker's gaze) to guide their expectations about objects on the basis of labeling information. The 9-month-olds in the current study did not see the objects while they were being labeled. The experimenter labeled the object pairs while the pairs were inside a closed box. Thus, the infants had to infer that the labels being provided referred to the unseen contents of the box. Future studies may manipulate more directly the direction of the experimenter's gaze to see if infants are sensitive to that information in this context.

Second, infants begin to comprehend words for object categories at around 9 months of age. One controversial issue is whether these early words are count nouns that refer to kinds or proper names that refer to individual objects. According to the literature, older children (2- to 4-year-olds) seem to assume that a novel word applied to an unfamiliar object refers to a basic-level kind (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Hall, 1991; Imai, Gentner & Uchida, 1994; Markman & Hutchinson, 1984; Soja et al., 1991; Waxman & Gelman, 1986; Waxman & Hall, 1993; Waxman & Kosowski, 1990) and will be extended to objects of similar shape (and kind; Baldwin, 1989; Jones, Smith, & Landau, 1991; Landau et al., 1988; Landau, Smith, & Jones, 1998; Smith, Jones, & Landau, 1992, 1996). Thus, for expert word learners, novel words are thought of as count nouns that can be readily generalized to like objects. But what remains an open question is whether this representation of novel words operates similarly in children just beginning to learn words. In other words, whether infants show evidence that their earliest labels for objects are count nouns that map onto kinds.

Although the current study did not involve actual word learning, the findings do inform the literature on early word extension. Research on word generalization has found that infants, as young as 13 to 15 months of age, will extend a newly learned label beyond the target object to other members of like kind (Woodward, Markman, & Fitzsimmons, 1994). What has not yet been demonstrated is whether younger infants, who are just on the cusp of word learning, also understand that words for objects are count nouns that refer to kinds. It could be that these very young infants expect that object labels simply designate individuals and, thus, function as proper names (Hirsh-Pasek, Golinkoff, Hennon, & Maguire, 2004; Smith, 2000). However, the current findings suggest that a "proper-name bias" in young word-learners may be untenable. If, for 9-month-olds at least, words serve as proper names and map to individuals, it should have been the case that there was no differentiation between looking times in each of the conditions (because in each trial, the box opened to reveal two individual objects). This scenario was not supported by the evidence. When two labels were used, 9-month-olds expected to see objects that differed along a kind-relevant property dimension (shape), but they did not expect to see objects that differed along a property dimension that was independent of kind membership

(color). Thus, even for young infants, the presence of different labels leads to the assumption that those labels correspond to objects that are distinct in kind. Such a finding is clearly suggestive that, at the beginning of word learning, infants understand words for objects as count nouns that designate kinds.

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