Developmental Psychology
2005, Vol. 41, No. 3, 491–505

0012-1649/05/$12.00 DOI: 10.1037/0012-1649.41.3.491

Conceptual Information Permeates Word Learning in Infancy

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Three experiments document that conceptual knowledge influences lexical acquisition in infancy. A novel target object was initially labeled with a novel word. In both yes–no (Experiment 1) and forced-choice (Experiment 2) tasks, 2-year-olds' subsequent extensions were mediated by the conceptual description of the targets. When targets were described as artifacts, infants extended on the basis of shape. When targets were described as animates, infants extended on the basis of both shape and texture. Experiment 3 revealed similar results for 1.5-year-olds. These results challenge the notion that expectations in word learning (e.g., the "shape bias") (a) emerge late and (b) rest entirely on correlations between perceptual object features and words. Instead, the results indicate that both perceptual and conceptual information permeate word learning in infancy.

Keywords: word learning, conceptual knowledge, shape bias, infancy

Recent research with infants and toddlers resounds with two clear conclusions. First, infants and toddlers have an impressive store of conceptual knowledge. Second, they acquire new words at a rapid rate. Infants' and toddlers' conceptual knowledge and word-learning prowess have far-reaching consequences for subsequent development. It is therefore important to consider whether and how these two processes interact. Mounting evidence suggests that they are intimately linked from an early age.

A considerable body of research has documented that word learning supports the early acquisition and organization of conceptual knowledge in infancy. First, for infants on the threshold of word learning, naming highlights commonalities among objects and, in this way, supports the establishment of fundamental categories of objects (e.g., car, animal). By 9 months, this effect is specific to words, because tones (matched to the words for amplitude, frequency, and duration) do not facilitate categorization (Balaban & Waxman, 1997). By 15 to 18 months, this facilitative effect of novel words is sufficiently powerful to support the formation of completely novel categories of objects (Booth & Waxman, 2002a; Fulkerson & Haaf, 2003).

In addition to supporting object categorization, word learning also serves as an efficient conduit for gaining information about individual objects, categories of objects, and events, including information that is not readily available from observation and perceptual sources alone. For example, information about the origin of objects (e.g., that kittens come from cats; that trees grow from seeds) or the meaning of some verbs (e.g., *give* vs. *take*) would be hard won through anything other than a linguistic route (Fisher & Gleitman, 2002).

Finally, word learning provides the infant with a source of support for inductive inference. For example, in a now-classic study, S. A. Gelman and Markman (1987) introduced preschool-age children to an individual object (e.g., a sparrow), taught them a novel, nonobvious fact about it (e.g., that it feeds mashed up food to its young), and then examined their patterns of induction for that fact. In the absence of any labels for the target and test objects, children extended the target fact only to other objects bearing a strong perceptual resemblance to the target object (e.g., a bat), and not to other members of the same category as the target (e.g., a flamingo). However, when the target and test objects were named, children performed differently, extending the target fact to the test object (e.g., the flamingo) that shared a name with the target (e.g., *bird*) even if the perceptual similarity was low. This phenomenon has also been documented in 2-year-olds (S. A. Gelman & Coley, 1990). More recently, Graham, Kilbreath, and Welder (2004) demonstrated similar effects of labeling on inductive inference in 13-month-old infants (also see Welder & Graham, 2001). After demonstrating a nonobvious property (e.g., that an object squeaks when it is squeezed) on a novel target object, they gave infants an opportunity to explore other objects that varied in their perceptual similarity to the target. Of interest was whether infants would attempt to elicit the nonobvious property on these test objects. In the absence of any labels for the target and test objects, infants' attempts were limited; they tried to elicit the hidden property only for the test object that bore the greatest perceptual resemblance to the target. However, when the target and test objects were labeled with the same novel word, infants' attempts to produce the property were much broader. This is important because it suggests that even for infants as young as 13 months of age, word learning guides induction regarding the nonobvious properties of objects. Taken together, the studies reviewed here suggest that word learning supports the establishment of the very foundations of conceptual structure in infancy.

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This research was supported by National Institutes of Health (NIH) Grant HD-28730 to Amy E. Booth and NIH Grant HD-08595-02 to Sandra R. Waxman.

We are grateful to the infants and caretakers who participated in these studies. We are also indebted to Jessica Hackenberg for her assistance with data collection.

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There is also considerable evidence that the causal arrow points in the other direction as well, with conceptual information guiding early word learning. Consider, for example, object function. In many cases, the function of a given object (e.g., a corkscrew) is not obvious from inspection of the object itself but is instead conveyed either by demonstration (e.g., by opening a wine bottle) or by description (e.g., by remarking that it is required for opening bottles with corks). Recent evidence indicates that conceptual knowledge regarding object function guides word learning from an early age. Diesendruck, Markson, and Bloom (2003) labeled a novel target object for 3-year-olds and asked them to extend the newly learned name to one of two test objects. One test object was perceptually similar to (e.g., was the same shape as) the target but could not perform the same function. The other was perceptually different (e.g., was a different shape) from the target but could perform the same function. In a baseline condition, children extended the novel word primarily to the perceptually similar test object. However, when the experimenter provided children with information regarding the object's intended function (i.e., what it was made to do), they revealed a very different pattern, preferring the test object that was perceptually different from the target but that shared its function. Kemler Nelson (1995) also documented that object function influences word extension in preschoolers. When the function of a labeled target object was demonstrated, children (ranging in age from 3 to 6 years) were more likely to extend the label to a new object that could be inferred to function like the target (despite global perceptual dissimilarity) than to one that could not be inferred to function like the target (despite global perceptual similarity; also see Kemler Nelson, Frankenfield, Morris, & Blair, 2000). Evidence that conceptual information regarding function guides the extension of novel words has now been documented in children as young as 2 years of age (Kemler Nelson, 1999; Kemler Nelson, Frankenfield, et al., 2000; Kemler Nelson, Russell, Duke, & Jones, 2000; Nelson, 1973).

There is also strong evidence that the ontological status of a given object influences word learning (Keil, 1994; Landau, 1994; Lavin & Hall, 2001). For example, when an individual object is described as a kind of animal, 3- to 4-year-old children tend to extend a novel name applied to that object to other objects sharing the same shape. Yet when the same individual object is described as a kind of rock, children's patterns of extension are quite different. They now accept wide variations in shape, extending the label on the basis of color and texture instead (Keil, 1994). Lavin and Hall (2001) also documented the influence of ontological domain in word learning at 3 years of age. In their study, one test object matched the labeled target in shape but differed in substance (color, texture, or smell). The other matched the target in substance but differed in shape. Children were more likely to extend the novel word to the same-shaped test object if the target was described as a toy than if it was described as food.

In sum, there is considerable evidence suggesting that infants' and toddlers' conceptual knowledge and word-learning prowess are closely entwined. Most contemporary theories of word learning reflect this state of the evidence, claiming that in the process of word learning, infants weave together information from various sources, including perceptual, social, pragmatic, and conceptual sources (Golinkoff et al., 2000; Hall & Waxman, 2004). However, this view has not been unilaterally endorsed. On the contrary, in an influential ongoing program of research, Linda Smith, Susan Jones, and their colleagues have argued that word learning "primarily engages the perceptual systems and is immune to influences from general world-knowledge" (Landau, Smith, & Jones, 1998, p. 20; also see Jones & Smith, 2002; Jones, Smith, & Landau, 1991; Landau, Smith, & Jones, 1988; Samuelson, 2002; Smith, 1995, 1999; Smith, Jones, & Landau, 1996; Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002).

According to this perceptual associationist view, instead of taking advantage of all available sources of information, early word learning is encapsulated from conceptual knowledge and is grounded solely in the child's capacity to detect associations among perceptual properties of objects, syntactic cues, and the words in his or her own productive vocabulary. Once these associations have been detected and stored, they are then triggered automatically in the context of learning novel words. It is by virtue of this automaticity, in which word learning is sequestered from the relatively slow deliberative processes that characterize conceptual processing, that early lexical acquisition is thought to proceed with such exceptional speed.

As in any associationist model, the correlations that are most consistent in the input are presumably most readily detected and learned. According to the perceptual associationist view, children first link words with shape-based commonalities among named objects, an association that they detect once they have acquired a critical mass of 50 count nouns in their productive vocabularies (Samuelson & Smith, 1999). The claim is that at this developmental juncture, word learning changes from an initially unconstrained process to a constrained process in which children now automatically extend novel nouns to objects that share the same shape with a labeled target object even if they differ on other salient dimensions such as size, texture, or color (e.g., Graham & Poulin-Dubois, 1999; Landau et al., 1988). This *shape bias* is said to emerge in a rather coarse, undifferentiated state, applying equally to objects from both the animate and artifact domains (Smith, 1999).

However, the perceptual associationist account further proposes that as children acquire a more extensive lexicon, they begin to notice more precise correlations between words and perceptual features. For example, they notice that most objects with eyes (a perceptual feature) tend to be organized rather tightly around texture as well as shape (e.g., mice are furry and alligators are scaly) but that those without the perceptual feature "eyes" vary widely in texture (e.g., chairs can be made of plastic, wood, metal, or stuffed plush fabric; Jones & Smith, 2002). In the perceptual associationist view of word learning, by roughly 3 years of age, children detect and store these more finely drawn associations among perceptual features, and these in turn become triggered automatically in the context of learning new words (Jones et al., 1991). For example, by the time a child is 3 years old, when a novel object without eyes is labeled with a novel noun, the shape bias is triggered, and as a result, children extend the noun to all objects that share shape with the named object regardless of their texture. Yet when a novel object with eyes is labeled, children extend the word to other objects that share both shape *and texture* with the named object. Eyes are not the only perceptual feature to have this effect. Putting shoes on labeled objects also leads 3-year-olds to extend words on the basis of both shape and texture (Jones & Smith, 1998).

Although the perceptual associationist account has been quite influential, it has weaknesses at both the descriptive and explanatory levels. First, the overall developmental pattern appears to vary across studies. In some studies, as predicted by the core theory (e.g., Smith, 1999), a coarse shape bias (applied generally to objects with and without eyes) emerges first and later gives way to more differentiated patterns of extension (Jones et al., 1991, Experiment 1). In other studies, however, the shape bias emerges in a way that is more constrained than the theory would predict. In some studies, the shape bias is initially evident only for objects without eyes (Jones & Smith, 2002); yet in other studies, it is reliably stronger for objects with eyes (Jones et al., 1991, Experiment 2). It is unclear how these specific patterns of effects can be accommodated by the broader perceptual associationist proposal. Also problematic is the cut-off point at which a shape bias is said to emerge. In some studies, the cut-off is placed at 50 count nouns in the child's productive vocabulary (Jones et al., 1991), yet in others, the cut-off is set at 75 (Jones & Smith, 2002). To the best of our knowledge, no explanation for this moving cut-off has been articulated. More troubling, however, is the fact that a correlation between productive vocabulary size and the expression of a shape bias has yet to be replicated in other laboratories (see Diesendruck & Bloom, 2003, and Graham & Poulin-Dubois, 1999, for failures to replicate).

The deeper problems, however, are those that engage the issues at an explanatory level. First, it is unclear why the ability to detect the relevant associations should rest on the number of words that learners can *produce*, when we know that learners must also be sensitive to correlations in the words that they *comprehend* but do not yet produce on their own. More generally, it is difficult to see why a theory of early word learning should lean so exclusively on correlations among perceptual units and eschew so stringently any conceptual input. After all, words, like other symbols, are quintessentially abstract. And ultimately words are semantic units that tie intimately into the conceptual system. Consider, for example, count nouns such as *bottle* or *dog*. Surely there are perceptual commonalities among the individuals named by these nouns. But just as surely, conceptual commonalities guide their extension as well (Madole & Oakes, 1999). Moreover, when we move beyond concrete nouns, we quickly encounter words for which the perceptual grounding is thin. There is nothing perceptual about the meanings of *wise* or *justice*. And perceptual information will never permit a learner to distinguish between the meanings of *chase* versus *flee* (Gillette, Gleitman, Gleitman, & Lederer, 1999). What this means is that an associationist account must involve a two-step process (either with one step to account for words that refer to entities that share a perceptual resemblance and a different step for those that refer to entities that do not, or with one step for early word learning and a later step to admit conceptual information into the process) and a mechanism for transitioning from the first to the second step. Thus far, no such mechanism has been proposed.

But the most important problem with the perceptual associationist account is that it fails to rule out key competing alternatives. In particular, it does not rule out the possibility that word learning and conceptual organization are linked from the start, with each taking input from a variety of sources, including each other. In this more integrative approach, in which perceptual, conceptual, and lexical acquisition proceed hand in glove, at least some of the apparently low-level perceptual effects described by Smith and her colleagues are seen to be mediated through conceptual knowledge (Becker & Ward, 1991; Booth & Waxman, 2002b; Diesendruck et al., 2003; S. A. Gelman & Medin, 1993; Keil, 1994; Landau, 1994). We have argued that eyes (and shoes) play an important role in word extension not because they automatically trigger attention to both shape and texture, but because they each signal the ontological status of the object being named (i.e., animacy). This conceptual knowledge of animacy then guides attention to the most relevant object properties.

In previous work, we provided direct empirical support for this interpretation (Booth & Waxman, 2002b). We designed an experiment in which we held the perceptual properties of labeled target objects constant, varying only their conceptual status (as in Keil, 1994, and Lavin & Hall, 2001). Children were randomly assigned to either an animate or artifact condition. Children in both conditions were introduced to the same target objects and heard these targets named with the same novel word within the context of a short vignette. The vignette described the target either as an animate object (e.g., "has a mommy and daddy who love it very much") or as an artifact (e.g., "was made by an astronaut to do a special job on her spaceship"). We then examined word extension for each target, expecting to find a differentiated pattern, with children in the artifact condition extending primarily on the basis of shape (as opposed to texture or size) and those in the animate condition extending on the basis of both shape and texture (but not size). The results mirrored this prediction precisely. Children's patterns of extension differed systematically as a function of the conceptual information provided in the vignettes. Because the objects presented in each condition were precisely the same perceptually, the results cannot be explained by a purely perceptual account.

However, data from 3-year-olds cannot speak to the origin of this phenomenon and therefore cannot fully resolve the debate over the nature of the earliest phases of word learning. Therefore, in the current experiments, we focused on 2-year-olds (Experiments 1 and 2) and then 1.5-year-olds (Experiment 3). This approach required that we (a) identify some piece of conceptual knowledge that infants have available to them and (b) assess whether this conceptual knowledge influenced their patterns of extension for novel words. What piece of conceptual information might satisfy this first requirement? Following on our previous work, we focused on infants' core knowledge regarding animacy.

A considerable body of research reveals that infants and toddlers are especially interested in animate objects. They devote special attention to faces from birth (e.g., Mondloch et al., 1999; Umilta, Simion, & Valenza, 1996), and by the time they are 2 years of age, they view human beings (and other objects with eyes) as intentional agents (Baldwin & Baird, 2001; Carpenter, Akhtar, & Tomasello, 1998; S. Johnson, Slaughter, & Carey, 1998; S. C. Johnson, Booth, & O'Hearn, 2001; Woodward, 1999). Most important for the issues at hand, by approximately 18 months of age, infants are sensitive to a distinction between animate and inanimate objects, and this distinction appears to have a conceptual (as well as perceptual) component (e.g., Carey, 1995; Mandler & McDonough, 1998a; McDonough & Mandler, 1998; Meltzoff, 1995; Rakison & Poulin-Dubois, 2001; Spelke, Phillips, & Woodward, 1995; Woodward, 1998). For example, Mandler and McDonough (1998b) demonstrated that 14-month-olds have specific expectations for the behaviors of animals that do not extend to artifacts and vice versa. After an experimenter used a target object (e.g., a dog) to model a domain-appropriate action (e.g., drinking), infants were more likely to imitate that action on other novel objects from the target domain (e.g., a fish) than from the contrasting domain (e.g., a bus). In principle, then, conceptual information regarding animacy should be available early enough to influence word learning in infancy.

To discover whether this is the case, we designed a series of experiments for infants that we based on the logic of our previous work with preschool-age children (Booth & Waxman, 2002b). If early word learning is permeated by conceptual information from the start, then 1.5- and 2-year-olds' word extensions, like those of 3-year-olds, should be guided by their appreciation, however rudimentary, of the conceptual distinction between artifacts and animate kinds. By moving our focus to infants, however, we faced two rather different investigative challenges. First, there was the methodological challenge of modifying the task to accommodate the limited behavioral capacities of these younger learners. The second challenge was of a more substantive nature. Although we suspect that the conceptual distinction between artifacts and animate kinds is available to infants, we also suspect that this distinction is less articulated and less elaborate than that of older children. As a result, when we assess whether conceptual knowledge regarding animacy influences patterns of extension for novel words, the effects might be attenuated in infants compared with older children.

Experiment 1

We began by extending the paradigm developed for 3-year-olds in Booth and Waxman (2002b) to include 2-year-olds. All children saw the same novel target objects labeled with the same novel word (a count noun, e.g., *dax*). To vary the conceptual status of these named objects, we created brief vignettes that described them either as animate objects (e.g., "has a mommy and daddy who love it very much") or as artifacts (e.g., "was made by an astronaut to do a special job on her spaceship"). We then examined children's extension of these newly learned words, predicting that the conceptual status of the named objects would influence the patterns of word extension for 2-year-olds just as it did for 3-year-olds (Booth & Waxman, 2002b).

Method

Participants

Twenty-four 2-year-olds (13 boys and 11 girls) with a mean age of 30.66 months (range = 26.35 to 33.85 months) were included in the final sample. All were recruited from Evanston, IL, and its surrounding communities and were acquiring English as their native language. The final sample included primarily Caucasian infants from middle- and upper-middle-class families. An additional 10 infants were excluded for failure to demonstrate that they understood the task. They either failed to extend the novel word to the identity match ($n = 2$) or failed to reject the unrelated distractor ($n = 8$). Six infants were also excluded for their failure to provide clear responses on at least half of the trials because of fussiness ($n = 3$) or for failure to respond ($n = 3$).

Materials

The stimuli consisted of two sets of six solid objects. Each set included a target object, an identity match (an exact replica of the target), three dimension-change test objects (each of which differed from the target on a single dimension), and a distractor (a carrot for the *dax* set and a metal wheel for the *riff* set). See Figure 1 for an illustration of both sets of stimuli.

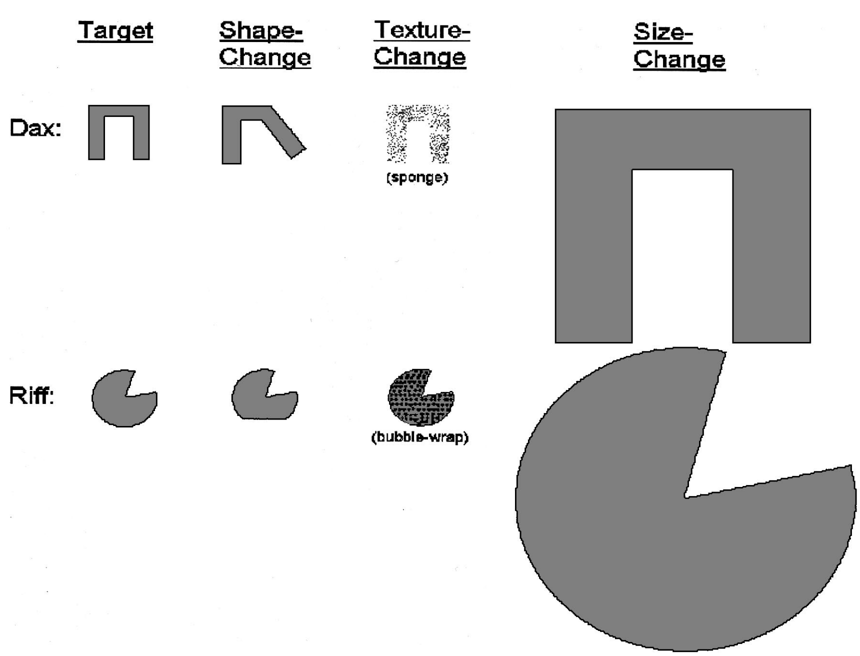

Figure 1. Stimuli used in Experiment 1. The size-change test object was four times larger than the target for the *dax* set and five times larger for the *riff* set. The texture-change test object was made of sponge for the *dax* set and was covered with bubble-wrap for the *riff* set.

Procedure

Infants were tested individually in the laboratory, in a procedure nearly identical to that used in Booth and Waxman (2002b). Infants were randomly assigned to either an animate or an artifact condition. Participants in both conditions saw the same stationary objects and heard the same novel labels throughout the 10-min procedure. What differed was the vignette with which a target object was introduced (see Appendix A for the complete set). Although the *dax* stimuli were always presented first, the assignment of vignettes to targets was counterbalanced within each condition.

Training phase. The experimenter presented the *dax* target, saying "Wow, look at this *dax*! I have something very special to tell you about this *dax*. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say." She then described the target object as either an animate kind (e.g., "This *dax* has a mommy and a daddy who love it very much. They love it so much that when this *dax* goes to sleep at night, they give it lots of hugs and kisses.") or an artifact (e.g., "This *dax* was made by an astronaut to do a very special job on her spaceship. The astronaut always takes her *dax* with her when she flies to the moon.").[1]

Test phase. With the target object visible, the experimenter explained, "Now I am going to show you some other things. Each one might be a *dax* or it might not be a *dax*. I need you to tell me if you think each one is a *dax* or is not a *dax*, ok?" She then presented the test objects in that set individually, asking for each, "Is this another *dax*?" The test phase began with the identity match. The remaining test objects were presented in random order.

After all four test trials were completed, the experimenter elicited a second set of judgments, saying, "Now, just so I have got it right, let us try this one more time." She then provided a one-sentence summary reminder of the story and repeated the *dax* test trials in the same order. The entire procedure was then repeated with the *riff* set.

Predictions

We expected that 2-year-olds would bring their considerable conceptual knowledge to bear in the task and that this would be reflected in their patterns of word extension. We expected infants in the artifact condition to extend novel words primarily on the basis of shape and those in the animate condition to extend on the basis of both shape and texture. We therefore predicted that infants in both conditions would accept the size-change test objects and reject the shape-change test objects but that performance in the two conditions would diverge on the texture-change test objects, with infants in the artifact condition being more likely than those in the animate condition to accept texture-change test objects.

Results

The results are summarized in Figure 2. For each infant, we calculated the proportion of "yes" responses (out of 2) for each type of test (i.e., shape change, texture change, size change). These three proportions were submitted to a mixed model analysis of variance (ANOVA) with condition (2: animate vs. artifact) serving as a between-subjects factor and test type (3) as a within-subject factor. A main effect of condition revealed that infants in the artifact condition extended the novel word to more test objects than did infants in the animate condition, $F(1, 22) = 6.01, p = .02$. This is consistent with our prediction. The expected interaction between condition and test type was marginal, $F(1, 21) = 2.93$, $p = .08$.

We next tested our predictions more directly by conducting three orthogonal comparisons across conditions, one for each test type. As predicted, performance in the artifact and animate conditions did not differ on either shape-change (*M*s [*SE*s] = .13 [.06] vs. .29 [.13]), $t(22) = 1.17$, *ns*, or size-change test trials (*M*s [*SE*s] = .98 [.02] vs. 1.00 [0]), $t(22) = 1.00$, *ns*. As predicted, the only reliable difference between these conditions emerged on the texture-change test trials. Infants in the artifact condition were more likely than those in the animate condition to accept texture-change test objects as referents of the novel words (*M*s [*SE*s] = .90 [.14] vs. .54 [.06]), $t(22) = 1.89, p = .03, d = .66$. This pattern was also reflected in the responses of individual infants (see Table 1). In the animate condition, nearly half of the infants consistently rejected the texture-change test objects. Yet in the artifact condition, not a single infant revealed this strong response pattern.

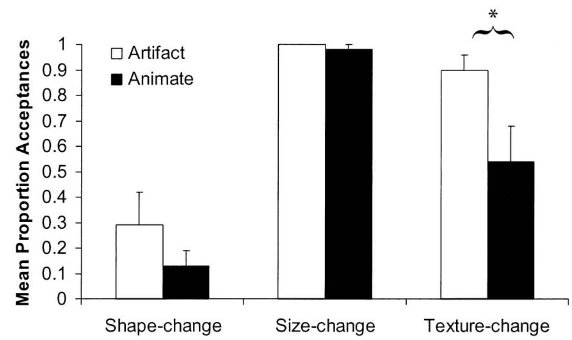

Figure 2. Mean proportion of acceptances of each type of test object as an appropriate referent for the novel words presented in each condition of Experiment 1. Vertical rules depict standard errors. $*p < .05$.

Discussion

As predicted, 2-year-olds extended novel words differently as a function of the conceptual status of the object being labeled. Infants in the artifact and animate conditions were equally likely to accept size-change test objects and to reject shape-change test objects. However, their performance differed markedly on the texture-change test trials. As predicted, infants in the artifact condition were more willing than infants in the animate condition to extend novel words to texture-change objects. This difference in performance must be attributed to the conceptual information provided in the vignettes because infants in both conditions saw precisely the same objects.

To chart the origins of this phenomenon, we next sought evidence from still younger word learners. Because yes–no tasks like that used in Experiment 1 are not well-suited to infants who tend to reveal strong "yes" biases, we developed a forced-choice method to better accommodate their behavioral capacities (see

[1] In Experiment 1 only, simple questions (e.g., "Who loves this *dax*/*riff* very much?" or "Where did Danny go to buy a new *riff*/*dax*?") were interjected throughout the vignettes presented to ensure that the infants remained engaged in the task. Because this was merely a repetition task, most infants responded correctly to these questions. In each case they were praised with a neutral "That is right!" Infants who did not respond, who said "I don't know," or who provided an incorrect statement were reminded of the correct information in a single simple recast that did not include the trained word (e.g., "Remember, its mommy loves it very much).

Table 1
Number of Infants in the Artifact and Animate Conditions of Experiment 1 Who Said "Yes" to Each Test Object 0, 1, or 2 Times

Response	Artifact	Animate
Shape change		
0 (no, no)	8	8
1 (no, yes)	1	4
2 (yes, yes)	3	0
Size change		
0 (no, no)	0	0
1 (no, yes)	0	1
2 (yes, yes)	12	11
Texture change		
0 (no, no)	0	5
1 (no, yes)	3	2
2 (yes, yes)	9	5

Bauer & Mandler, 1989; Jones & Smith, 2002). In Experiment 2, we used this method with 2-year-olds to ensure that it tapped the same knowledge as the yes–no task. In Experiment 3, we went on to extend this method to 1.5-year-old infants.

Experiment 2

The basic design mirrored that of Experiment 1. All infants were presented with the same novel objects labeled by the same novel count nouns. The only difference between conditions was in the vignettes, which described the target objects either as artifacts or as animate objects. We predicted that the conceptual status of the named objects would influence 2-year-olds' patterns of word extension in this forced-choice task, just as it did in the yes–no task of Experiment 1 (Booth & Waxman, 2002b).

Method

Participants

Thirty-two 2-year-olds (15 boys and 17 girls) with a mean age of 29.78 months (range = 25.63 to 33.91 months) were included in the final sample. All were recruited from Evanston, IL, and its surrounding communities. The final sample included primarily Caucasian infants from middle- and upper-middle-class families. All were acquiring English as their native language. Their productive count noun vocabularies averaged 92 and ranged from 5 to 298 as assessed by the MacArthur Communicative Development Inventories (CDI; Fenson et al., 1993, 1994). Three additional 2-year-olds were excluded either because they failed to extend the novel words to an exact replica of the target object (n = 2) or because they failed to respond on more than half of the test trials (n = 1).

Materials

We designed two sets of stimuli, each including 12 objects: 1 target, 1 identity match, 2 different shape-change test objects, 2 different texture-change test objects, 2 different size-change test objects, and 4 novel distractors (which differed from the target on all three dimensions under consideration). See Figures 3 and 4 for illustrations of the complete stimulus sets. A colorful box was also constructed for each set, large enough to contain each individual object. A small rectangular plastic

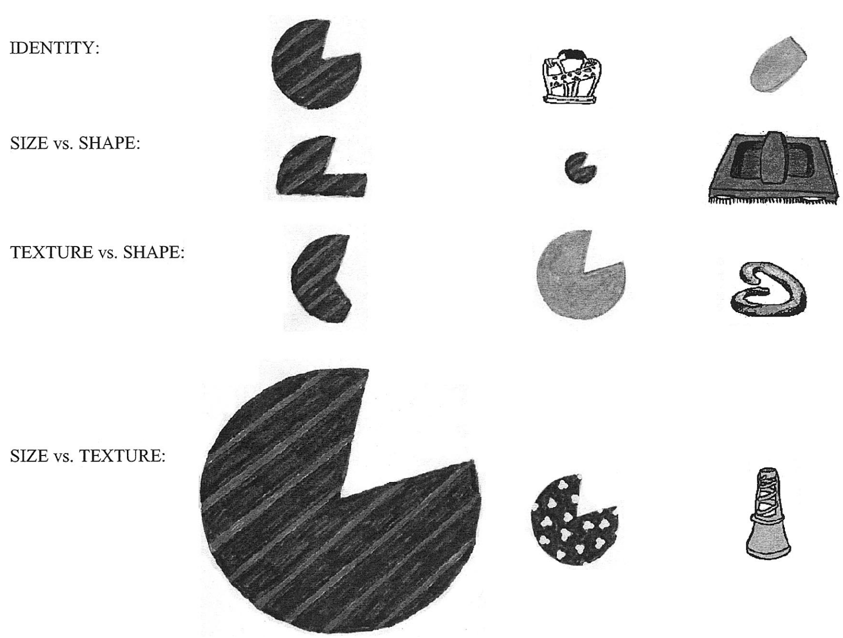

Figure 3. The *riff* set of stimuli presented in Experiments 2 and 3. The target was carved from a 3-in. (7.6-cm) diameter block of Styrofoam and was painted purple with red stripes. One size-change test object was 3.33 times larger than the target; the other was approximately half the size of the target. One texture-change test object was covered in yellow clay; the other was painted blue and dotted with y-shaped yellow beads.

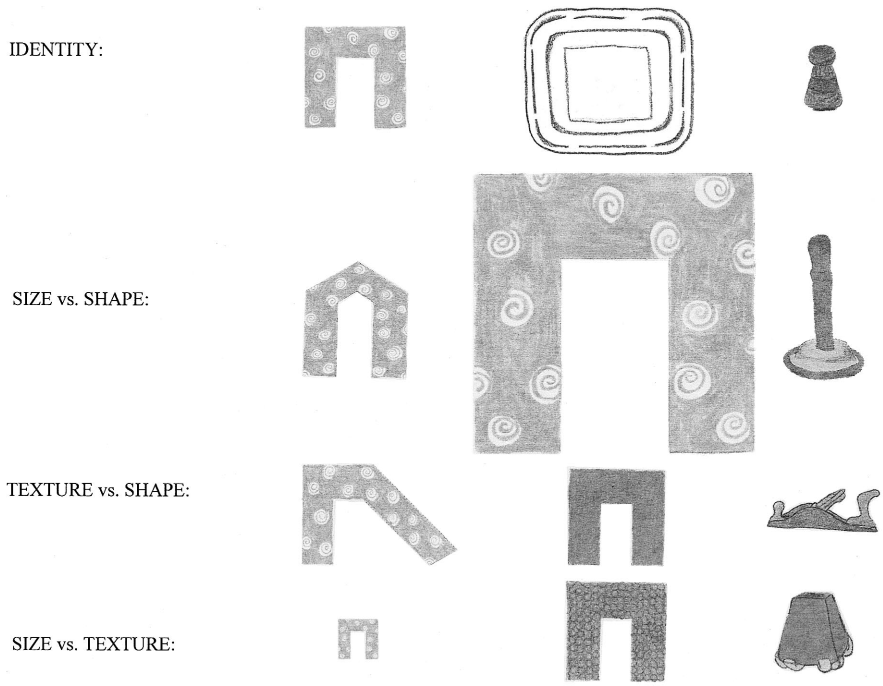

Figure 4. The *dax* set of stimuli presented in Experiments 2 and 3. The target object was carved from a 3 × 3 × 1.5 in. (7.6 × 7.6 × 3.8 cm) block of Styrofoam and was painted green with white spirals. One size-change test object was 2.67 times larger than the target; the other was approximately half as big as the target. One texture-change test object was painted purple and covered with bubble wrap; the other was constructed out of wood and painted orange.

container, a piece of white cloth, and a 2-in.-long dark brown plastic block were also used as props.

Procedure

Infants were randomly assigned to the animate or artifact condition. Participants in both conditions saw the same objects and heard the same novel labels throughout a two-phase procedure that lasted approximately 10 min. What differed was the vignette with which the objects were introduced. The *dax* stimulus set was always presented first, but the assignment of vignettes to targets was counterbalanced within each condition. In what follows, we illustrate the procedure using one example of an animate vignette. Please see Appendix B for the complete set of vignettes and the wording used throughout. It is important to note that although we used minimal props and gestures to help illustrate the information presented in the vignettes and to maximize the infant's attention, the props and gestures were closely matched across conditions. For example, the lip puckering used to demonstrate kissing in the animate condition looked the same as the lip puckering used to demonstrate putting out the fire in the artifact condition. Therefore, the gestures themselves provided no distinctive information relevant for determining the domain membership of the target objects. This design feature is critical for excluding a perceptually based explanation of the results.

Training phase. The experimenter began by presenting a stimulus box along with the target object from the *dax* set, saying, "Look at this box! A *dax* lives in this box. Only *daxes* are allowed in this box. Let's see if we can find the *dax* inside the box." After removing the *dax* from the box, she continued, "This is a *dax*. This *dax* has a mommy who loves it very much. When this *dax* goes to sleep at night, its mommy gives it lots of kisses like this." The experimenter then gave the *dax* a kiss and asked the child, "Can you give the *dax* a kiss good-night too? I think this *dax* is getting pretty sleepy now. Let's say night-night to the *dax* now." The experimenter then placed the *dax* in a small container, covered it with a cloth, and put it back in the large box while saying, "Let's put the *dax* back in its house."

The next phase of the training period was designed to facilitate infants' abilities to make choices among objects. The experimenter said, "While the *dax* is napping, let's look at some other things." At this point, she introduced two distractors, saying, "Look at these! These are not *daxes*. This one is not a *dax* and this one is not a *dax*." She then removed the distractors and said, "Wait, I think I hear the *dax*. I think the *dax* woke up!" She then removed the target *dax*, this time saying, "Let's play a game with the *dax*. This *dax* lives all by itself and it is very lonely. Let's help it find some other *daxes* to live with." The experimenter then laid the two distractor objects along with the identity match test object on the table and said, "I'm looking for another *dax*. Where's another *dax*?" She picked up one of the distractors and said, "Is this a *dax*? No! That's not a *dax*! See, it can't go in the box." After putting the distractor down, the experimenter continued, "Where is another *dax*?" She picked up the other distractor and repeated, "Is this a *dax*? No! That's not a *dax*! See, it can't go in the box either." She then put the second distractor down. At this point, she picked up the identity match, saying, "How about this one? Yay! This one is a *dax*! Let's put the *dax* in the box."

Test phase. The test phase consisted of four trials, each including three different objects (see Figures 4 and 5). The experimenter began by saying, "Now it is your turn!" On each trial, the infant was allowed to play freely with three test objects. The experimenter retrieved these objects after 10 s. She then reintroduced the target object and placed the three test objects in front of the infant in a random arrangement. While holding the target object in full view of the infant, the experimenter asked, "Can you find another *dax*? Can you put another *dax* in the box?" Infants were praised for their responses regardless of which object they chose. The identity test trial was always presented first. On this trial, infants chose between the identity test

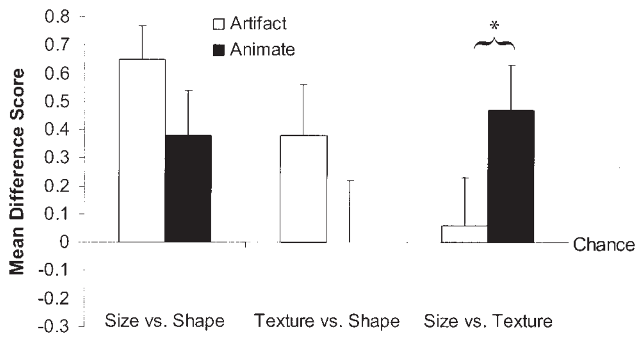

Figure 5. Mean difference scores for each type of test trial presented to 2-year-olds in Experiment 2. Vertical bars depict standard errors. $^{*}p < .05$ (one-tailed).

object and two distractors. The remaining three dimension-change test trials were presented in random order. Each included two different dimension-change test objects and one distractor. One trial pitted size against shape, another pitted texture against shape, and the third pitted size against texture (see Figures 3 and 4).

After the training and test phases were completed with the *dax* set, the entire procedure was repeated with the *riff* set.

Coding and Data Reduction

We calculated the proportion of trials (out of 2) on which each child chose each of the dimension-change test objects. Next, to provide an index of the children's preferences for word extension on each type of test trial, we calculated difference scores. On size versus shape trials, a positive value reflects a preference for size changes over shape changes in word extension. On texture versus shape trials, a positive value reflects a preference for texture changes over shape changes. On size versus texture trials, a positive value reflects a preference for size changes over texture changes.

Predictions

If the forced-choice task taps into the same competencies as the yes–no task, then performance in the current experiment should mirror that observed in Experiment 1. We therefore expected infants in the artifact condition to extend novel words primarily on the basis of shape and infants in the animate condition to extend on the basis of both shape and texture. Within the context of the current design, then, our predictions were as follows: On size versus shape test trials, infants in both conditions should prefer size changes. On texture versus shape trials, infants in the artifact condition should prefer texture changes over shape changes, but infants in the animate condition should show a less clear-cut preference because both texture and shape should be considered relevant dimensions in word extension. On size versus texture trials, we expected to find a clear difference between the conditions. We predicted that infants in the artifact condition would show no preference (because neither dimension figures largely in their word extension), whereas infants in the animate condition would prefer size changes (because they consider texture, but not size, relevant to word extension).

Results

Overall, the results (as summarized in Figure 5 and Table 2) provide support for the predictions. First, notice that infants rarely chose the distractor (see Table 2). This suggests that they had a good understanding of the task. More important, infants in the artifact condition extended novel words primarily on the basis of shape, whereas those in the animate condition extended on the basis of both shape and texture (see Figure 5). As described in the *Coding and Data Reduction* section above, we first calculated three difference scores for each infant, one for each test type (size vs. shape, texture vs. shape, and size vs. texture), to capture their responses to each qualitatively different dimensional contrast. Next, to examine their patterns of performance across test trials and conditions, we submitted these difference scores to a mixed model ANOVA with condition (2: animate vs. artifact) as a between-subjects factor and test type (3: size vs. shape, texture vs. shape, size vs. texture) as a within-subject factor. There were no main effects. A significant interaction between condition and test type revealed that, as predicted, infants' preferences for word extension on the various test types varied as a function of the domain membership ascribed to the target objects, $F(2, 60) = 3.15$, $p = .05$.

We next tested our predictions more directly by conducting three orthogonal comparisons across conditions, one for each test type. On size versus shape test trials, there was no difference between conditions, $t(30) = 1.49$, *ns*. Infants in both the artifact and animate conditions revealed a preference for size changes that exceeded the level predicted by chance (0): $M = .66$, $SE = .11$, $t(15) = 6.01$, $p = .01$, and $M = .38$, $SE = .15$, $t(15) = 2.42$, $p = .03$, respectively. This finding is consistent with the view that for both artifacts and animate objects, shape is an important dimension in word extension. On texture versus shape trials, there was also no difference between conditions, $t(30) = 1.31$, *ns*. However, comparisons with chance performance revealed that infants in the artifact condition preferred texture changes over shape changes ($M = .38$, $SE = .18$), $t(15) = 2.09$, $p = .05$, and that infants in the animate condition revealed no preference ($M = 0$, $SE = .22$), $t(15) = 1$, *ns*. This finding is consistent with the view that for artifacts, shape is relevant to word extension, but that for animates, both shape

Table 2
Mean Proportion of Test Trials on Which Each Type of Test Object Was Chosen in the Artifact and Animate Conditions of Experiment 2

	Artifact		Animate	
Test object	*M*	*SE*	*M*	*SE*
Size vs. shape				
Size change	.78	.06	.69	.08
Shape change	.13	.06	.31	.08
Distractor	.09	.05	0	0
Texture vs. shape				
Texture change	.69	.09	.50	.11
Shape change	.31	.09	.50	.11
Distractor	0	0	0	0
Size vs. texture				
Size change	.50	.08	.72	.08
Texture change	.44	.09	.25	.08
Distractor	.06	.04	.03	.03

and texture are relevant. Finally, consider the size versus texture trials. Here, as predicted, we found a reliable difference between the conditions, $t(30) = 1.80$, $p = .04$ (one-tailed), $d = 1.00$.[2] Infants in the artifact condition revealed no preference ($M = .06$, $SE = .16$), $t(15) = 0.38$, *ns*, but infants in the animate condition preferred size changes ($M = .47$, $SE = .15$), $t(15) = 3.03$, $p = .01$. This pattern of response is consistent with the view that neither texture nor size figures heavily in extending words applied to artifacts but that texture (and not size) figures heavily in extending novel words applied to animate objects.

These results are reflected in the individual response patterns summarized in Table 3. In the artifact condition, only 3 infants out of 16 consistently chose the size-change over the texture-change test object, whereas in the animate condition, 8 of the 16 revealed this strong response pattern.

Discussion

The results from the forced-choice task mirror precisely those obtained in the yes–no task of Experiment 1 and provide converging evidence that by 2 years of age, the conceptual status of a named object influences word extension. In both Experiments 1 and 2, 2-year-olds extended novel words primarily on the basis of shape for artifacts and on the basis of both shape and texture for animate objects. This finding is noteworthy because it provides the earliest demonstration that children's word extension varies as a function of ontological categories. In previous work, when word extensions for objects with and without eyes (or shoes) were compared, a differentiated pattern did not emerge until 3 years of age (Jones & Smith, 1998, 2002; Jones et al., 1991). How can we reconcile these earlier reports with the current findings? Taken together, the evidence suggests that the conceptual information provided in our vignettes might be more powerful than perceptual features (e.g., eyes) alone in guiding children's lexical acquisition. We return to this issue in the General Discussion.

Table 3
Number of Infants in the Artifact and Animate Conditions of Experiment 2 Who Did and Did Not Choose Each Test Object Consistently

Response	Artifact	Animate
Size vs. shape		
Consistently size change	9	7
Inconsistent	7	8
Consistently shape change	0	1
Texture vs. shape		
Consistently texture change	8	6
Inconsistent	6	4
Consistently shape change	2	6
Size vs. texture		
Consistently size change	3	8
Inconsistent	10	7
Consistently texture change	3	1

Experiment 3

In Experiment 3, we used the forced-choice task to ask whether conceptual information influences word learning in infants at 1.5 years of age. We specifically selected infants with fewer than 50 count nouns in their productive vocabularies, which enabled us to test the claim that a shape bias in word learning does not emerge in advance of this cut-off (Jones & Smith, 2002; Jones et al., 1991; Landau et al., 1988; Smith et al., 2002).

Because in our view, word learning is linked to conceptual knowledge from the start, we predicted that infants would draw on their conceptual knowledge in this word-learning task. However, we suspected that their conceptual knowledge might be quite rudimentary at this developmental moment and that their ability to recruit this conceptual knowledge in the service of word learning might be attenuated relative to older children. There are two reasons why this might be the case. First, infants' success in revealing a differentiated pattern of word extension rests on their ability to identify the domain membership of the labeled target on the basis of the vignettes alone. This may be easier in the animate than in the artifact condition because it is likely that concepts such as *eating*, *sleeping*, and *loving* are more familiar to infants than concepts such as *bought at a store*, *kept in a box*, and *cleaned in a sink*. Moreover, the concepts included in the animate vignettes are unambiguously restricted to the animate domain, but most of the concepts included in the artifact vignettes could, in principle, be applied to animate kinds as well as to artifacts.

Second, even if infants do succeed in identifying the domain membership of the labeled target object, they might still fail to extend the words differently in the two conditions because they have not yet discovered which dimensions are most relevant to these distinct domains. Because the domain of artifacts appears to be defined by less consistent regularities than the animate domain, it may take infants longer to isolate the important dimensions for the former than for the latter.

Given these complexities, we made two levels of predictions for the infants in the current study. At a global level, we expected a shape bias to be evident for infants in both conditions. Although the evidence for a shape bias in children so young is decidedly mixed, we expected that attention to shape would emerge very early, thanks to the shape-based organization of most object categories within and outside the context of language (see Diesendruck & Bloom, 2003, for evidence that the shape bias is not a purely linguistic phenomenon). At a more specific level, we expected to find different patterns of word extension in the artifact and animate conditions. Although we expected that performance in the animate condition would mirror that of the 2-year-olds, we suspected that performance in the artifact condition would be weaker and less clearly organized at 1.5 years than at 2 years. As discussed above, this follows from the observation that core notions regarding animacy may be developmentally privileged relative to notions regarding inanimate objects (e.g., Mandler, 1992; Massey & Gelman, 1988).

[2] On the basis of strong predictions following from the results of Experiment 1 (as well as the results of Booth & Waxman, 2002b), a one-tailed test is warranted here and for the same comparison made in Experiment 3.

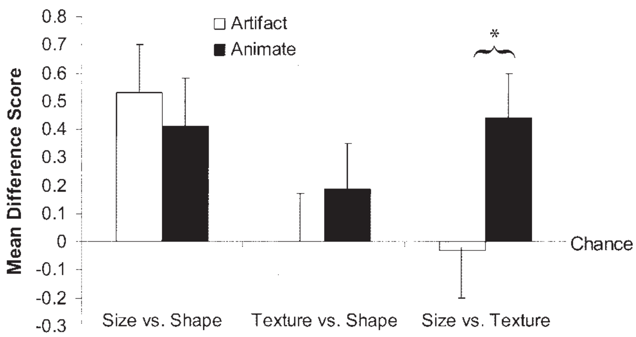

Figure 6. Mean difference scores for each type of test trial presented to 1.5-year-olds in Experiment 3. Vertical bars depict standard errors. $*p < .05$ (one-tailed).

Method

Participants

Thirty-two infants with a mean age of 19.58 months (range = 17.99 to 22.24 months) participated. All were recruited from Evanston, IL, and its surrounding communities. The sample included primarily Caucasian infants from middle- and upper-middle-class families. We selected infants who were acquiring English as their native language and who were producing fewer than 50 count nouns. The final sample included infants with a mean productive vocabulary of 18 count nouns (range = 0 to 49 count nouns) as assessed by the MacArthur CDI (Fenson et al., 1993, 1994). Several infants were replaced either because they failed to select the identity match on both identity test trials ($n = 10$) or because they selected the distractor on 50% or more of the test trials ($n = 17$). There were no systematic distinctions (in age, gender, ethnicity, or vocabulary level) between infants who successfully completed the procedure and those who did not.

Materials

The materials were identical to those used in Experiment 2.

Procedure

The procedure was identical to that used in Experiment 2.

Coding and Data Reduction

Coding and data reduction proceeded as in Experiment 2.

Predictions

We expected that infants in both conditions would reveal a shape bias in their extensions of novel words. We further predicted that conceptual information regarding the ontological status of a named object would also come into play. More specifically, infants in the artifact condition were expected to extend novel words primarily on the basis of shape, whereas those in the animate condition were expected to extend them on the basis of both shape and texture. Two additional points bear mention. First, because 1.5-year-old infants' conceptual knowledge is less elaborate than that of older children and adults, we suspected that the distinction between the artifact and animate conditions might be less pronounced here than in Experiment 2. Second, because conceptual knowledge regarding animate kinds is likely more coherent than that regarding artifacts, we suspected that the patterns of extension in the animate condition would be more clear-cut than those in the artifact condition.

Results

The results are summarized in Figure 6 and Table 4. Although infants chose the distractor choices at a rate of 18% (see Table 4), clear patterns did emerge (see Figure 6).

We first conducted a new analysis to test the prediction that these younger infants would reveal a global shape-based pattern of response (note that we did not make this prediction for the older infants). In this analysis, we focused on the two types of test trials for which a shape-based response was possible (i.e., texture vs. shape and size vs. shape). For each infant, we tabulated the number of trials (out of a possible 4) on which they chose the same-shaped test object, and we then compared performance in each condition to the chance level (1.33). As predicted, infants in both the artifact and animate conditions selected the same-shaped alternative at a rate that exceeded chance responding: $M = 2.13$, $SE = 0.29$, $t(15) = 2.81$, $p = .01$, and $M = 2.19$, $SE = 0.23$, $t(15) = 3.81$, $p = .002$, respectively.

Next, following the analytic strategy developed in Experiment 2, we computed difference scores to examine infants' performance on each test type (3: size vs. shape, texture vs. shape, and size vs. texture) and in each condition (2: animate vs. artifact). A mixed model ANOVA revealed a marginal main effect of condition, $F(2, 60) = 2.81$, $p = .07$, suggesting that infants' preferences in extending novel words were more pronounced in the animate than in the artifact condition.

We next tested our predictions more directly by conducting three orthogonal comparisons across conditions, one for each test type. On size versus shape test trials, there was no difference between conditions, $t(30) = 0.55$, *ns*. Here, infants in both the artifact and animate conditions revealed a preference for size changes that exceeded the level predicted by chance (0): $M = .53$, $SE = .16$, $t(15) = 3.30$, $p = .01$, and $M = .41$, $SE = .16$, $t(15) = 2.55$, $p = .02$, respectively. This finding is consistent with the view that shape is an important dimension for word extension for both

Table 4
Mean Proportion of Test Trials on Which Each Type of Test Object Was Chosen in the Artifact and Animate Conditions of Experiment 3

	Artifact		Animate	
Test object	*M*	*SE*	*M*	*SE*
	Size vs. shape			
Size change	.72	.09	.66	.09
Shape change	.19	.08	.25	.08
Distractor	.09	.05	.09	.05
	Texture vs. shape			
Texture change	.38	.07	.44	.08
Shape change	.38	.10	.25	.08
Distractor	.25	.09	.31	.08
	Size vs. texture			
Size change	.41	.08	.63	.09
Texture change	.44	.11	.19	.08
Distractor	.16	.06	.18	.08

Table 5
Number of Infants in the Artifact and Animate Conditions of Experiment 3 Who Did and Did Not Choose Each Test Object Consistently

Response	Artifact	Animate
Size vs. shape		
Consistently size change	9	7
Inconsistent	6	8
Consistently shape change	1	1
Texture vs. shape		
Consistently texture change	1	2
Inconsistent	12	13
Consistently shape change	3	1
Size vs. texture		
Consistently size change	2	6
Inconsistent	9	9
Consistently texture change	5	1

artifacts and animate objects. On texture versus shape trials, there was also no difference between conditions, $t(30) = 0.95$, *ns*, and neither condition differed from chance responding: $M = 0$, $SE = .14$, $t(15) = 0$, *ns*, and $M = .19$, $SE = .14$, $t(15) = 1.38$, *ns*, respectively. This outcome suggests that these young infants may be rather unclear about the relative status of shape- versus texture-based commonalities in word extension. Finally, consider the size versus texture trials. Here, as predicted, we found a reliable difference between the conditions, $t(30) = 2.00$, $p = .03$ (one-tailed), $d = .73$. Infants in the artifact condition revealed no preference ($M = -.03$, $SE = .19$), $t(15) = 0.17$, *ns*, whereas infants in the animate condition preferred size changes ($M = .44$, $SE = .14$), $t(15) = 3.05$, $p = .01$. This pattern of responding is consistent with the view that neither size nor texture figures heavily in extending words applied to artifacts but that texture (and not size) is relevant in extending words applied to animate objects.

These results are reflected in the individual response patterns summarized in Table 5. In the artifact condition, only 2 out of 16 infants consistently chose the size-change over the texture-change test object, whereas in the animate condition, 6 infants revealed this strong response pattern.

General Discussion

The current experiments reveal that conceptual information guides word learning in infants as young as 20 months of age. In each of three experiments, infants' extensions of novel words varied systematically as a function of the conceptual status of the named object. When objects were described as artifacts, 1.5- and 2-year-old infants extended novel words primarily on the basis of shape. When the same objects were described as animate kinds, infants extended words on the basis of both shape and texture. These distinct patterns document that infants attended to the conceptual information provided in our vignettes and used it to guide their extensions of novel words. Moreover, the fact that the specific comparisons underlying this global characterization of the data yielded substantial effect sizes suggests that the influence of conceptual information is important.

These results are inconsistent with the claim that word learning is initially impervious to conceptual information (Jones & Smith, 2002; Jones et al., 1991; Smith, 1995, 1999; Smith et al., 1996, 2002). In particular, these results call into question the assertion that early word learning is the product of automatic generalizations made exclusively on the basis of perceptually based correlations embedded in the child's own productive vocabulary. According to this account, only after having acquired a productive lexicon that includes at least 50 count nouns are children able to detect even the broadest correlation between count nouns and shape-based commonalities. Yet infants in Experiment 3, with an average of only 18 count nouns in their productive vocabularies, not only revealed an overall shape bias for both artifacts and animate kinds but also revealed distinct patterns of extension for animate objects and artifacts. There is, of course, reason to be cautious in interpreting this evidence, because there was a rather high attrition rate with this youngest sample. Nonetheless, the fact remains that neither the overall shape bias exhibited by these infants nor their differentiated pattern of extensions in the artifact and animate conditions can be accounted for within the current version of the perceptual associationist framework.

Why were the infants in the current experiments so precocious relative to those in prior studies (e.g., Jones & Smith, 2002; Jones et al., 1991; Landau et al., 1988; Smith et al., 2002)? We suggest that this finding, in itself, may be evidence for the power of conceptual information in early word learning. In the current experiments, infants were verbally provided with conceptual information regarding the labeled target objects. In contrast, in most of the work supporting the perceptual associations view, conceptual information either was absent entirely or was available only indirectly (via the presence or absence of perceptual features such as eyes and shoes). The relative precocity observed in the current experiments suggests that when infants are assigning meaning to a novel word, conceptual information may be more powerful than perceptual input alone. This interpretation is consistent with the fact that infants in the animate condition of the current experiments extended the novel words in a domain-appropriate manner despite the fact that the stimuli did not, in fact, *look* like animate objects. Moreover, in earlier work, we explicitly tested the relative contributions of perceptual and conceptual information (Booth & Waxman, 2002b, Experiment 2). We presented 3-year-olds with objects with a strong perceptual cue to animacy (eyes) but described them as artifacts (using the artifact vignette). In the face of this conflicting information, children extended novel words in accordance with the conceptual information (i.e., as if the objects were artifacts). This is not to say that conceptual information is always more powerful than perceptual information in determining the referents of novel words. Our claim is much more measured: that conceptual information permeates infants' interpretations of novel words and that this permeation is evident in their patterns of extension.

This claim is consistent with the domain-specific patterns of extension observed in each of our three experiments. Among these, we find the performance of the youngest infants (Experiment 3) especially intriguing. Although 1.5-year-olds' patterns of extension precisely mirrored those of the 2-year-olds in the animate condition, their responses were somewhat less coherent in the artifact condition. There, 1.5-year-olds showed a clear preference to preserve shape on size versus shape test trials, which suggests that they viewed shape as essential in extending novel words applied to artifacts. However, this preference to preserve shape was not evident on texture versus shape test trials, in which infants were equally likely to select the texture-change and shape-change test objects. This finding suggests that although infants prefer shape over size, they are less clear when it comes to the relative import of shape and texture. As previously discussed, infants' organization in the artifact domain may be limited by two relevant factors. First, it may have been more difficult for infants to unambiguously identify the ontological status of the target object from the artifact vignettes than from the animate vignettes. Although there is evidence that infants associate the activities mentioned in our animate vignettes (e.g., *eating* or *sleeping*) with animate objects (Mandler & McDonough, 1996, 1998b; McDonough & Mandler, 1998), we are aware of no such parallel evidence that they connect the activities mentioned in our artifact vignettes (e.g., *being used for a specific purpose* or *being bought at a store*) specifically with artifacts at this early age (see S. A. Gelman & Bloom, 2000; S. A. Gelman & Kremer, 1991; Kelemen, 1999). And there may be good reason for this lack of evidence, because these activities are not, in fact, exclusive to artifacts: Some animals (e.g., horses, dogs, pigeons) can be *used for a specific purpose*, and others (e.g., pets) can be *bought at a store*. Second, infants may not have developed sufficiently clear expectations regarding the relative import of various dimensions (e.g., shape, texture, size) within that domain. Given the greater variability of artifacts than animate kinds, it is possible that it just takes longer for infants to recognize these consistencies in dimensional import.

Clearly, the current data do not permit us to distinguish between these two possibilities. However, they do fortify the claim that a conceptual distinction between animate kinds and artifacts is present prior to the infant's 2nd birthday and that it influences word learning well before the infant has amassed a large productive vocabulary. Our data are also consistent with the notion that all similarities are not created equal across all domains of knowledge (e.g., Keil, 1994; Landau, 1994; Lavin & Hall, 2001). Our data add to the existing literature by demonstrating that these relative weights are in place (at least for the animate domain) by 18 to 22 months of age. It will be important in future work to discover how this knowledge develops. Although it is possible, in principle, that these weightings are innately specified (consistent with, e.g., the work of R. Gelman, 1990), it seems unlikely that 1.5-year-olds could appreciate the causal relations between texture and animacy. We suspect that infants at this age are not yet aware that the *reason* that texture is important for animals is because it is causally related to their adaptations for survival in their specific habitats (i.e., for protection from the relevant elements, for camouflaging from predators, and for attracting mates). It is entirely possible, then, that these relations are initially learned through associative mechanisms similar to those described by proponents of the perceptual associationist account. However, because differentiated patterns of extension were observed so early in the current study, our data suggest, contrary to the perceptual associationist view, that this learning process cannot be attributed to the process of word learning alone (see Diesendruck & Bloom, 2003).

This discussion raises a time-honored issue in the cognitive developmental literature focusing on the relationship between perceptual and conceptual information (see Madole & Oakes, 1999). From our perspective, no true dichotomy exists between these sources of information. Rather, perceptual and conceptual information represent the endpoints on a continuum of abstraction away from sensory input. Although much of our conceptual knowledge can be derived from information closer to the perceptual end of this continuum, much of it cannot. For example, knowledge of how machines and biological organisms function, what their origins are, what their insides are like, and what drives their behavior is rarely obtained from direct observation. We agree with the notion that the causal explanations that underlie this type of knowledge and that impose a coherent order on perceptual correlations are essentially conceptual in nature (e.g., Barrett, Abdi, Murphy, & Gallagher, 1993; S. A. Gelman & Medin, 1993; Mandler, 1993; Medin, 1989; Murphy, 1993)

In conclusion, we have argued for an inclusive view of word learning in which very young learners capitalize on a variety of inputs, including those derived from both perceptual and conceptual sources. In contrast to predictions stemming from the perceptual associationist view, our data reveal that infants as young as 1.5 years of age (a) are guided by biases or expectations in interpreting the meaning of novel words and (b) bring their conceptual knowledge (however rudimentary it may be) to bear in word learning. Indeed, we suspect that as soon as conceptual knowledge is available to infants, they will recruit it broadly and effectively across a range of tasks. This has already been demonstrated for categorization (e.g., Gopnik & Sobel, 2000; Kemler Nelson, Frankenfield, et al., 2000), inductive reasoning (e.g., S. A. Gelman & Markman, 1986; Mandler & McDonough, 1996), and problem solving (e.g., Brown, 1990; Kemler Nelson, 1999). In the current experiments, we provide the clearest and earliest documentation yet that this is also the case for word learning (see also Diesendruck et al., 2003; Gopnik & Sobel, 2000; Keil, 1994; Kemler Nelson, 1999; Kemler Nelson, Russell, et al., 2000; Landau, 1994; Lavin & Hall, 2001; Nelson, 1973).

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Appendix A

Experiment 1 Vignettes

Animate 1

"Wow, look at this *dax/riff*! I have something very special to tell you about this *dax/riff*. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. This *dax/riff* has a mommy and a daddy who love it very much. They love it so much that when this *dax/riff* goes to sleep at night, they give it lots of hugs and kisses."

Animate 2

"Wow, look at this *riff/dax*! I have something very special to tell you about this *riff/dax*. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. This *riff/dax* is usually very hungry. One day when it was walking through the forest, this *riff/dax* found 6 candy bars. And it was so happy when it found them that it jumped up and down and gobbled up all the chocolate."

Artifact 1

"Wow, Look at this *dax/riff*! I have something very special to tell you about this *dax/riff*. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. This *dax/riff* was made by an astronaut to do a very special job on her spaceship. The astronaut always takes her *dax/riff* with her when she flies to the moon."

Artifact 2

"Wow, look at this *riff/dax*! I have something very special to tell you about this *riff/dax*. Do you want to hear it? Listen carefully now because I am going to ask you some questions about what I say. Danny usually keeps this *riff/dax* in his basement. But one day Danny took it outside because he needed to use it to fix something. When his *riff/dax* got worn out doing the job, Danny went to the store and bought a new one."

Appendix B

Experiment 2 Vignettes

Animate 1

"Look at this box! A *riff* lives in this box. Only *riff*s are allowed in this box. Let's see if we can find the *riff* inside the box." After pulling out the *riff* she continued, "This is a *riff*. This *riff* has a mommy who loves it very much. When this *riff* goes to sleep at night, its mommy gives it lots of kisses like this." The experimenter then gave the *riff* a kiss and asked the child, "Can you give the *riff* a kiss good-night too? I think this *riff* is getting pretty sleepy now. Let's say night-night to the *riff* now." The experimenter then put the *riff* in a small container, covered it with a cloth, and put it back in the large box while saying, "Let's put the *riff* back in its house." She then continued, "While the *riff* is napping, let's look at some other things." As she pulled out the distractors, she exclaimed, "Look at these! These are not *riff*s. This one is not a *riff* and this one is not a *riff*." She then removed the distractors and said, "Wait, I think I hear the *riff*. I think the *riff* woke up!" As she pulled out the target *riff* again she said, "Let's play a game with the *riff*. This *riff* lives all by itself and it is very lonely. Let's help it find some other *riff*s to live with." The experimenter then laid the two distractor objects and the identity match test object on the table while saying, "I'm looking for another *riff*. Where's another *riff*?" While picking up one of the distractors she said, "Is this a *riff*? No! That's not a *riff*! See, it can't go in the box." After putting the distractor down, the experimenter continued, "Where is another *riff*?" She picked up the other distractor and repeated, "Is this a *riff*? No! That's not a *riff*! See, it can't go in the box either." She then put the second distractor down and picked up the identity match, saying, "How about this one? Yay! This one is a *riff*! Let's put the *riff* in the box."

Animate 2

"Look at this box! A *dax* lives in this box. Only *daxes* are allowed in this box. Let's see if we can find the *dax* inside the box." After pulling out the *dax* she continued, "This is a *dax*. This *dax* is usually very hungry. One day when this *dax* was walking through the forest, it found some chocolate!" The experimenter moved the *dax* up and down while saying, "The *dax* jumped up and down because it was so happy!" She proceeded to pretend to feed the *dax* some chocolate (a brown plastic block) while saying, "Then the *dax* gobbled up the chocolate like this. Can you feed the *dax* some chocolate too? The *dax* had so much chocolate that it brought some home to eat later. Wow! That *dax* ate a whole lot!" The experimenter then put the *dax* back in the large box while saying, "I think the *dax* needs to rest a while." She then continued, "While the *dax* is resting, let's look at some other things." As she pulled out the distractors, she exclaimed, "Look at these! These are not *daxes*. This one is not a *dax* and this one is not a *dax*." She then removed the distractors and said, "Wait, I think I hear the *dax*. I think the *dax* has rested long enough!" As she pulled out the target *dax* again she said, "Let's play a game with the *dax*. This *dax* has so much chocolate left over it needs some other *daxes* to share it with. Let's help it find some other *daxes*." The experimenter then lay the two distractor objects and the identity match test object on the table while saying, "I'm looking for another *dax*. Where's another *dax*?" While picking up one of the distractors she said, "Is this a *dax*? No! That's not a *dax*! See, it can't go in the box." After putting the distractor down, the experimenter continued, "Where is another *dax*?" She picked up the other distractor and repeated, "Is this a *dax*? No! That's not a *dax*! See, it can't go in the box either." She then put the second distractor down and picked up the identity match, saying, "How about this one? Yay! This one is a *dax*! Let's put the *dax* in the box."

Artifact 1

"Look at this box! A *riff* is kept in this box. Only *riff*s belong in this box. Let's see if we can find the *riff* inside the box." After pulling out the *riff* she continued, "This is a *riff*. A fireman bought this *riff* at the store. When the fireman puts out a fire, he uses his *riff* like this." The experimenter then held the *riff* to her mouth and aimed at a pretend fire. She then asked, "Can you use the *riff* to put out the fire too? Ugh! This *riff* is all dirty now from shooting goop at the fire." The experimenter then put the *riff* in a small container, scrubbed it once with a cloth, and put it back in the large box while saying, "Let's put the *riff* in the sink to get all the dirt off." She then continued, "While the *riff* is soaking in the sink, let's look at some other things." As she pulled out the distractors, she exclaimed, "Look at these! These are not *riff*s. This one is not a *riff* and this one is not a *riff*." She then removed the distractors and said, "I think the *riff* is clean now." As she pulled out the target *riff* again she said, "Let's play a game with the *riff*. Let's pretend there's another fire! This is a very big fire. We need other *riff*s to put out this fire. Let's find some other *riff*s." The experimenter then laid the two distractor objects and the identity match test object on the table while saying, "I'm looking for another *riff*. Where's another *riff*?" While picking up one of the distractors she said, "Is this a *riff*? No! That's not a *riff*! See, it can't go in the box." After putting the distractor down, the experimenter continued, "Where is another *riff*?" She picked up the other distractor and repeated, "Is this a *riff*? No! That's not a *riff*! See, it can't go in the box either." She then put the second distractor down and picked up the identity match, saying, "How about this one? Yay! This one is a *riff*! Let's put the *riff* in the box."

Artifact 2

"Look at this box! A *dax* is kept in this box. Only *daxes* belong in this box. Let's see if we can find the *dax* inside the box." After pulling out the *dax* she continued, "This is a *dax*. A little girl named Sally found this *dax* in her closet. Sally decided to use her *dax* to build a table." The experimenter pretended to hammer the brown plastic block with the *dax* while saying, "She hammered the *dax* up and down to get the blocks just right." She then held the plastic block horizontally and pretended to hammer the end of it while saying, "Then Sally used her *dax* like this. Can you help Sally build a table with the *dax*? Yay! She's all done building the table. Sally's really tired now." The experimenter then put the *dax* back in the large box while saying, "Let's put the *dax* away while she rests." She then continued, "While Sally is resting, let's look at some other things." As the experimenter pulled out the distractors, she exclaimed, "Look at these! These are not *daxes*. This one is not a *dax* and this one is not a *dax*." She then removed the distractors and said, "Wait, I think I hear Sally. She is ready to build something else now. She is going to build a playhouse." As she pulled out the target *dax* again she said, "Sally is going to need lots of *daxes* to build a big playhouse! Let's help her find some other *daxes*." The experimenter then laid the two distractor objects and the identity match test object on the table while saying, "I'm looking for another *dax*. Where's another *dax*?" While picking up one of the distractors she said, "Is this a *dax*? No! That's not a *dax*! See, it can't go in the box." After putting the distractor down, the experimenter continued, "Where is another *dax*?" She picked up the other distractor and repeated, "Is this a *dax*? No! That's not a *dax*! See, it can't go in the box either." She then put the second distractor down and picked up the identity match, saying, "How about this one? Yay! This one is a *dax*! Let's put the *dax* in the box."

Received March 2, 2004
Revision received January 7, 2005
Accepted January 10, 2005 ■