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Object Names and Object Functions Serve as Cues to Categories for Infants

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Can object names and functions act as cues to categories for infants? In Study 1, 14- and 18-month-old infants were shown novel category exemplars along with a function, a name, or no cues. Infants were then asked to "find another one," choosing between 2 novel objects (1 from the familiar category and the other not). Infants at both ages were more likely to select the category match in the function than in the no-cue condition. However, only at 18 months did naming the objects enhance categorization. Study 2 shows that names can facilitate categorization for 14-month-olds as well when a hint regarding the core meaning of the objects (the function of a single familiarization object) is provided.

Partitioning the world into meaningful categories is a formidable task, especially considering the vast amount of information that could be organized in the process. Nevertheless, infants succeed at forming a wide variety of categories within their first year of life (e.g., Quinn & Eimas, 1997; Mandler & McDonough, 1993). Although it is commonly assumed that processing biases in the infant can help to explain this remarkable ability, the precise nature of such constraints, and the mechanisms by which they exert their influence, have proved difficult to specify.

In this article, we attempt to articulate one possible means by which infants determine the intension of new categories. We propose that infants are biased to attend to a small set of cues that invite the careful comparison of objects to each other (see Nelson, 1974; Reznick, 2000; Ward, Becker, Hass, & Vela, 1991, for similar suggestions). By demarcating a restricted set of objects for processing, these cues substantially narrow the information to which infants attend in their attempts at categorization. As a result, infants may more readily detect other commonalities among objects that help to define their category membership.

To be most adaptive, these cues must reliably identify important categories and must be salient to infants. Object names and object functions both fit these criteria. Object names provide critical information by marking the categories about which older children and adults regularly communicate. Object functions (or perhaps intended functions) are critical cues to category membership for adults, particularly in the categorization of artifacts (Bloom, 1998; Rips, 1989; Miller & Johnson-Laird, 1976; but also see Gentner, 1978). In addition to marking important categories, object names and object functions are also salient to infants. Infants are able to parse object names from the ongoing speech stream within the first year of life (Balaban & Waxman, 1997; Jusczyk, 1995). Infants also become sensitive to relationships between the forms of objects and their functions within their first 2 years (e.g., Baldwin, Markman, & Melartin, 1993; Brown, 1990; Kemler Nelson, Russell, Duke, & Jones, 2000; Madole & Cohen, 1995; Madole, Oakes, & Cohen, 1993; Nelson, 1979).

Object names and object functions may be salient to infants for several reasons. For example, both implicitly embody a relationship between objects and human agents. Object names themselves are only arbitrary sounds, but they gain meaning in relation to the referential intent of the agent who produces them. Object functions (at least those of artifacts) are defined as the use, or intended use, of an object by an agent. Because it is well- known that infants are adaptively, perhaps evolutionarily, attracted to people (faces and voices) from near birth, the fact that human beings are critically associated with object names and object functions may enhance the salience of these cues (Jones-Molfese, 1977; Mondloch et al., 1999; Standley & Madsen, 1990; Valenza, 1998). Indeed, infants in their first year of life respond to objects differently when they have been named by an adult than when they have not (Balaban & Waxman, 1997; Waxman & Booth, 2001). We also know that infants as young as 6 months attend to adults interacting with novel objects with sufficient engagement to imitate them at a later time (e.g., Collie & Hayne, 1999; Hayne, Boniface, & Barr, 2000; Meltzoff, 1988; Meltzoff & Moore, 1993).

Object names and object functions may also be salient because they each have consequences for the infant. Object names support communication, which can foster learning and richer social interactions and provide better means for reaching desired outcomes (e.g., asking for the "bottle" rather than crying). Naming may help infants to orient toward the objects about which others are communicating, potentially supporting the acquisition of further knowledge (e.g., Baldwin & Markman, 1989). In addition, even before infants are able to speak, their ability to comprehend object names may support useful predictions about what objects will be found in the immediate environment when the word is heard, as well as inductions regarding the nonobvious properties of those objects (Nazzi & Gopnik, 2001; Welder & Graham, 2001). Object

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functions also have a direct impact on the infant in that they are often played out in dynamic events that culminate in a desirable outcome (e.g., a bottle provides a drink when sucked; a ball bounces when dropped). Observing adults using objects in functional ways provides a rich supply of information about how to effectively interact with the world (e.g., Meltzoff & Moore, 1994).

Recent research suggests that object names and functions do indeed highlight commonalities among objects for infants, and that these commonalities help infants to organize those objects into categories (Balaban & Waxman, 1997; Booth, 2001; Waxman & Markow, 1995). For example, infants pay more attention to category-relevant perceptual similarities among objects when they are labeled with a novel name than if no names are provided (Waxman & Markow, 1995). Neither nonreferential verbal phrases nor tones have the same facilitative effect (Balaban & Waxman, 1997). By 14 months of age, count nouns have become specifically associated with category-relevant commonalities among objects (Booth & Waxman, 2002a; Waxman & Booth, 2001).

Simple object functions (in the form of agent-produced motions) also seem to enhance infants' attention to other perceptible object features. Booth (2001) familiarized 14-month-old infants with exemplars from two similar-looking categories of novel objects that varied on four discrete visual dimensions, only two of which correlated with category membership. At test, infants were trained on a series of forced-choice trials to select exemplars from only one of these categories. Infants were most likely to succeed at this task, and to do so in fewer trials, if they observed the category-specific ways in which an agent could move the objects during familiarization. When infants were instead familiarized with equivalently dynamic, but nonfunctional features of the exemplars, they were less likely to respond consistently to the categories during testing. Thus, object functions, but not motions alone, enhanced infants' categorization.

In summary, the existing evidence suggests that both object names and object functions are salient to infants and facilitate the formation of early categories. Both appear to promote comparison among a restricted set of objects and to draw attention to category-relevant similarities and differences among objects. Unfortunately, however, because the studies addressing the influence of each of these cues differed in several ways, it is difficult to assess just how similar the effects of object names and functions are on categorization. First, these investigations have considered different aspects of the categorization process. Booth's (2001) investigation of object functions focused on infants' ability to detect differences between two perceptually similar categories, while the most relevant studies focusing on object names principally focused on infants' ability to detect commonalities among perceptually disparate sets of objects (Waxman & Booth, 2001; Waxman & Markow, 1995). Second, the studies utilized very different stimuli. Object functions were studied using novel artificial stimuli (e.g., abstract flower-like objects), while object names were studied using familiar stimuli (e.g., animals or cars). Finally, different experimental paradigms were used. Booth (2001) familiarized infants to 10 exemplars from each category before beginning a lengthy operant-conditioning testing procedure. In contrast, Waxman and her colleagues familiarized infants to just four exemplars from a single category before proceeding with a brief novelty preference task, a match-to-sample word extension task, or both.

A principal goal of the current research was to evaluate the object name and object function cues under equivalent conditions at both 14 and 18 months of age. We adopted the methodology successfully used by Waxman and Booth (2001, in press) with infants ranging from 11.5 to 24.0 months of age but used novel stimuli (as in Booth, 2001). Infants were familiarized to four different exemplars from a novel category and then asked to select between another object from that category and an object from a different category in a forced-choice test.

On the basis of previous research, we predicted that both object functions and names would facilitate categorization at both 14 and 18 months of age. However, we also considered the possibility that object functions and object names might not affect categorization in precisely the same manner. After all, although these two cues share many important characteristics, there are also fundamental differences between them. Perhaps most important, functions are integrally bound to categories by causal links to object structure, whereas words are arbitrarily assigned to categories within a linguistic community. This leads to the possibility that for infants on the brink of language acquisition, functions may provide a more compelling basis for categorization than words. If this were the case, then the relative power of these cues might shift between 14 and 18 months, as infants acquire a more substantial lexicon (e.g., Fenson et al., 1993).

Study 1

Method

Participants

Thirty-six 14- to 15-month-old infants (M = 14.59; range = 14.01–15.43 months) and thirty-six 17- to 18-month-old infants (M = 18.2; range = 17.60–18.95 months) participated. There were equal numbers of males and females in the total sample, with an approximately equal distribution of the sexes maintained across condition and age. All infants were recruited through mailings to homes in the greater Chicago area.

Materials

Thirty-two objects, all easily grasped and manipulated by infants, served as stimuli. The objects were organized into four sets, each containing five different objects from a single category and three additional objects drawn from different categories. All stimuli were three-dimensional objects created by the experimenter with colorful FIMO clay. Novel stimuli were created to ensure that the objects were completely unfamiliar to the infants, thus minimizing any potential influences of prior knowledge of their category membership, their functions, or their names. Although the individual objects in each category varied somewhat in shape, size, color, and patterning, their similarities in overall shape (Set A: blob-like, Set B: pot-like, Set C: peg-like, Set D: disk-like), color range (Set A: blues and greens, Set B: yellows and oranges, Set C: browns and grays, Set D: pinks and purples), and parts or pattern elements (Set A: loops and cross-hatching, Set B: lip bulges and base holes, Set C: rings and Velcro bases, Set D: spirals and squiggles) allowed adults to easily sort them appropriately. See Figure 1 for an illustration of the stimuli.

In addition to the stimuli, an apparatus was constructed on which the functions of the objects could be demonstrated. The apparatus consisted of (a) a hook on which objects from Set A could be hung and swung; (b) a clear plastic container filled with couscous, which could be scooped and sifted through objects from Set B; (c) a Velcro-topped platform mounted on a spring to which objects from Set C could be stuck and jiggled; and (d)

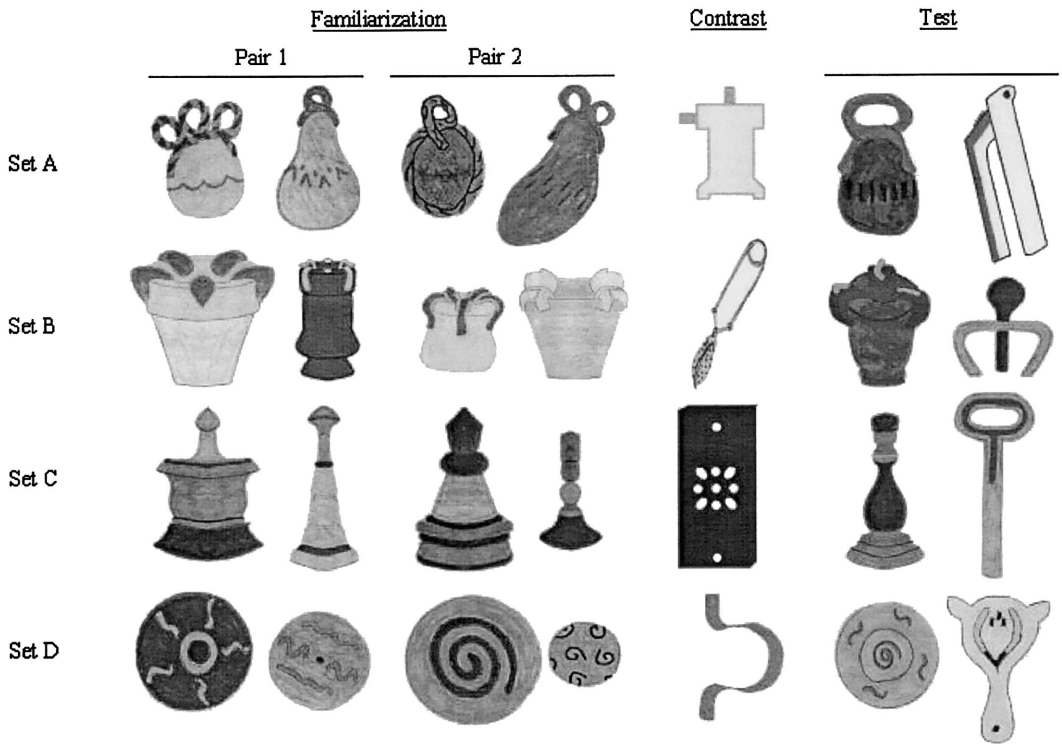

Figure 1. Illustrations of the four sets of stimuli used in each phase of both Study 1 and Study 2. Only one of the two contrast objects for each set is illustrated here. The colors comprising category members in Set A included shades of green and blue, and the out-of-category objects were orange, pink, white, and gold. Category members in Set B included shades of yellow and orange, and the out-of-category objects were silver, black, blue, green, and purple. Category members in Set C included shades of brown and gray, and the out-of-category objects were blue, yellow, green, and pink. Category members in Set D included shades of pink and purple, and the out-of-category objects were green, yellow, blue, and black.

a slide down which objects from Set D could be slid. The apparatus remained in a stationary position out of the infants' reach at all times.

Procedure

After being randomly assigned to one of three conditions (novel name, novel function, and no cue), infants completed a familiarization, contrast, and test phase with each of the four sets of stimuli (modified from Waxman & Booth, 2001).

Familiarization phase. Infants in all conditions were first familiarized with two pairs of objects, all of which were drawn from the same set. The experimenter introduced the first pair, attracting the infant's attention by exclaiming, "Look at these!" The experimenter then commented on each object individually. In the novel name condition, she said, "This one is a *dax* and this one is a *dax*." In the novel function condition she said "Look what I can do with this one and look what I can do with this one" as she demonstrated the function of each one on the appropriate apparatus (e.g., sifted the couscous). In the no-cue condition, she simply said "Look at this one and look at this one" while looking intently at each object in turn. The first pair of objects was then given to the infant for 15 s. Although the infants were able to play freely with the objects, they never had access to the apparatuses and therefore could not explore their function. After retrieving the objects, the experimenter then said "Remember . . . " and repeated her previous comments and/or demonstrations on them. She then followed the same procedure for the second pair of familiarization objects.

Contrast phase. Next, the experimenter held up an object from a contrasting category. She shook her head solemnly, saying "Uh oh! This one is not a *dax*" (novel name condition) or "Uh oh! I can't do that with this one" (novel function condition) or "Uh oh! Look at this one" (no-cue condition). In the novel function condition, she also demonstrated that the contrast object did not function in the same way as the familiarization objects (e.g., she tried but failed to scoop and sift the couscous). The experimenter then introduced the target object that was drawn from the original familiarization set. She happily exclaimed "Yay, this one is a *dax*" (novel name condition) or "Yay, I can do that with this one" (novel function condition) or "Yay, look at this one" (no-cue condition). In the novel function condition, she also re-demonstrated the target object's function once.

Test phase. At this point, the experimenter simultaneously presented the infant with the familiar category test object (e.g., a previously unseen member of the familiarization category) and the novel category test object. Infants played freely with these objects for 15 s, after which time the objects were retrieved and placed out of the infant's reach on the table. The experimenter then re-presented the target object, drawing attention to it by pointing and saying "Remember, this one is a *dax*" (novel name condition) or "Remember, I can do this with this one" as she demonstrated its function (novel function condition) or "Remember, look at this one" (no-cue condition). While pointing to the target object, she then asked the infant, "Can you find me another one of these?" She quickly pushed the test objects into the infant's reach, approximately 12 in. (30.5 cm) apart, and asked "Can you give me another one of these?" as she pointed to the target object and then to her hand. Because the functions or names of the test objects were not available, this task required the infants to infer category membership

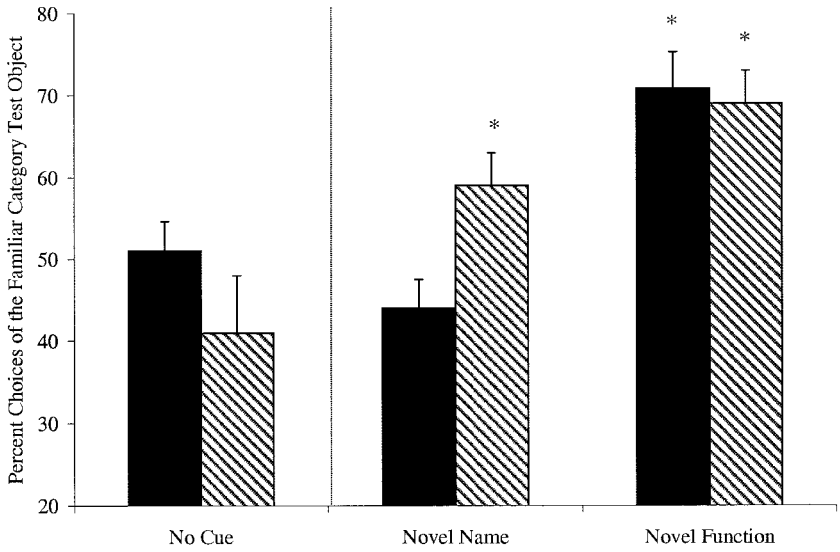

Figure 2. Percentage of 14- and 18-month-old infants' test object choices that corresponded to the familiar category in each condition of Study 1. Solid bars represent 14-month-olds; hatched bars represent 18-month-olds; asterisks represent $p < .05$ versus the no-cue condition.

from other static perceptual features of the objects that were correlated with the names or functions presented to them during familiarization.

The contrast and test phases were repeated once before proceeding with familiarization to the next set of stimuli. On this second round, a new contrast object was presented. Although the same target and test objects were presented on both the first and second tests, the left–right placement of the test objects was counterbalanced across the two trials.

Coding

The videotaped sessions were scored with the sound removed to ensure that the coders, who were blind to the experimental hypotheses, were also blind to condition assignment. Coders identified each infant's choice of test objects on each trial. If the infant put one of the test objects in the hand of the experimenter, it was recorded as the infant's choice. If the infant failed to give either object to the experimenter, the object that the infant touched first was recorded as the infant's choice. However, in these cases, no choice was recorded if the infant touched the second object within 2 s of the first. Clear choices were obtained on 98.4% of the trials. A primary coder scored all of the infants. A second coder independently scored 24 infants, evenly distributed across condition and age. Consistency was computed as the proportion of trials on which the coders agreed. Agreement was 96.0%. There were no systematic inconsistencies among coders. The few disagreements detected were easily resolved through jointly viewing the videotapes.

Results

We first conducted an omnibus analysis of variance to assess effects of age (14 vs. 18 months) and condition (no cue vs. novel name vs. novel function) on the proportion of test trials on which the familiar category test object was chosen.[1] This analysis revealed a main effect of condition, $F(2, 66) = 15.77$, $p < .001$, qualified by a Condition × Age interaction, $F(2, 66) = 4.17$, $p < .025$ (see Figure 2). To clarify the nature of this interaction, we analyzed the simple effects of condition at each age. A significant effect of condition emerged at both 14 months, $F(2, 33) = 12.93$, $p < .001$, and 18 months, $F(2, 33) = 8.20$, $p < .01$. However, the pattern of data underlying this effect differed across age. At 14 months, infants selected the familiar category test object more often in the novel function condition ($M = 71\%$) than they did in the novel name ($M = 44\%$) or no-cue ($M = 51\%$) condition (least significant difference [LSD]: ps $< .01$). The novel name and no-cue conditions did not differ. At 18 months, infants selected the familiar category test object more often in both the novel function ($M = 69\%$) and novel name ($M = 59\%$) conditions than in the no-cue ($M = 41\%$) condition (LSD: ps $< .025$). The novel function and novel name conditions did not differ. Thus, object functions facilitated categorization at both ages, but object names did so only at 18 months of age.

Because the preceding analyses cannot evaluate how consistently infants performed across the two test trials for each stimulus set, we tabulated the number of sets on which infants consistently chose the familiar category test object (i.e., chose the familiar category test object on both Test Trials 1 and 2), consistently chose the novel test object (i.e., chose the novel test object on both Test Trials 1 and 2), or made inconsistent choices (i.e., chose the familiar category test object on one test trial, but the novel test object on the other). These distributions (see Table 1) reflect the same pattern of results obtained from the parametric analyses. There was a significant effect of condition at both 14, $\chi^2(4, N = 36) = 19.25$, $p < .001$, and 18 months of age, $\chi^2(4, N = 36) = 16.18$, $p < .01$.

[1] Preliminary analyses revealed no interactions between stimulus set (Set A vs. B vs. C vs. D) or trial (Test 1 vs. Test 2) and the factors most pertinent to our predictions in Study 1 (i.e., age and condition) or Study 2 (i.e., condition). Therefore, in all subsequent analyses, we collapsed the data across these variables.

Table 1
Number of Consistently Familiar, Inconsistent, and Consistently Novel Responses Made by 14- and 18-Month-Old Infants in Each Condition of Study 1

Age and condition	Consistently familiar	Inconsistent	Consistently novel
14-month-olds			
No cue	9	31	8
Name	4	33	8
Function	22	24	2
18-month-olds			
No cue	8	23	17
Name	13	27	6
Function	17	27	1

To pinpoint the source of these effects, we conducted more specific comparisons between the conditions at each age. At 14 months, performance in the novel function condition differed reliably from that observed in the novel name, $\chi^2(2, N = 24) = 16.37$, $p < .001$, and no-cue, $\chi^2(2, N = 24) = 9.37$, $p < .01$, conditions, with a greater proportion of consistent familiar category choices being made in the novel function condition. The novel name and no-cue conditions did not differ. At 18 months, performance in the novel function and novel name conditions differed reliably from that observed in the no-cue condition: $\chi^2(2, N = 24) = 15.35$, $p < .01$ and $\chi^2(2, N = 24) = 6.73$, $p = .04$, respectively. The novel function and novel name conditions did not differ.

Discussion

The results from Study 1 support two major conclusions, one pertaining to object functions, the other to object names. First, object functions facilitate categorization in both 14- and 18-month-old infants. As predicted, when objects shared a common function (novel function condition), infants paid more attention to other static perceptual commonalities (e.g., shape, color, or part structure) among them that otherwise went unnoticed (no-cue condition). It is not yet clear, however, what it is about function that supports this effect. One possibility is that it is not object function per se, but rather object motion, that is critical. In the novel function condition, objects traversed distinctive paths of motion while executing their functions, and these motions alone could have enhanced categorization. After all, infants are highly sensitive to motion and use it to recognize objects from a very young age (e.g., Bertenthal, 1993; Kellman, 1993).

To address the possibility that motion, independent of function, was responsible for facilitating categorization, we tested an additional 24 infants (twelve 14-month-olds and twelve 18-month-olds) in a new motion only control condition. These infants were treated in precisely the same manner as those in the original novel function condition, with one exception: The experimenter moved the familiarization objects in the distinctive paths associated with their functions, but she did not demonstrate the functions themselves (e.g., objects from Set A were held *in front of* the hook and moved back and forth in a pendular motion). Infants in this motion only control condition failed to categorize the stimuli. At 14 months of age, infants in the motion only control condition selected the familiar category test object 42% of the time, a rate that differed from that found in the original novel function condition, $t(22) = 4.32$, $p < .01$, but not from that found in the no-cue or novel name conditions. At 18 months of age, infants in the motion only control condition selected the familiar category test object 40% of the time, a rate that differed significantly from that found in the novel function and novel name conditions, $t(22) = 5.31$, $p < .01$ and $t(22) = 3.31$, $p < .01$, respectively, but did not differ from that found in the no-cue condition.

The results from the motion only control condition demonstrate that the distinctive motions associated with object functions were not, by themselves, responsible for infants' successful categorization in the novel function condition. These results also rule out other spurious characteristics of the novel function condition (e.g., the language used during the introductory phrases, or the fact that objects were presented in the context of a specific apparatus) as viable explanations of the results.

The second major conclusion that can be reached from the results of Study 1 is that object names facilitate categorization at 18 months of age. However, object names did not have this facilitative effect at 14 months of age. This result was quite surprising. In previous research using a similar procedure (Booth & Waxman, 2002a; Waxman & Booth, 2001), 14-month-old infants were more likely to select a familiar category over a novel category test object after hearing a set of four familiarization objects labeled with the same novel count noun than if the objects were not labeled.

What can explain these conflicting results? We suggest that differences in the familiarity and meaningfulness of the stimuli may be responsible. Recall that Waxman and Booth (2001, in press) presented infants with small models of familiar objects (e.g., horses, cars) for which infants likely already had some associated core meaning, perhaps in the form of domain membership, underlying causal structure, or conditions of identity and individuation (e.g., Gelman & Coley, 1991; Gelman, Coley, & Gottfried, 1994; Medin & Ortony, 1989; Soja, Carey, & Spelke, 1991; Xu, 1999). In contrast, in the current study, we used completely novel objects for which infants could have no knowledge of any such core meaning.

This notion of core meaning may also help explain infants' success in the novel function condition. Here, core meanings for the novel stimuli may well have been provided by the object functions themselves (Nelson, 1974). Object functions are embodied in dynamic events that are rich in causal relations between agents, their actions, and the properties of the objects being acted upon. We suggest that this complex causal structure represents an excellent example of core meaning. If these conjectures are correct, then providing infants in the novel name condition with a hint regarding the core meaning of the novel stimuli should facilitate their categorization.

Study 2

In Study 2, we tested this hypothesis by providing infants with just such a hint. We demonstrated the function of the first (and only the first) familiarization object presented, and then compared performance of infants provided with this hint alone with that of infants provided with this hint in the context of naming (name + hint). If the facilitative effect of naming is in fact predicated on

infants' ability to detect some core meaning for the labeled objects, then when infants are provided with the hint (even in reference to a single object), naming should highlight category membership. We therefore predicted that infants in the name + hint condition would categorize more successfully than those in the hint alone control condition.

Method

Participants

Twenty-four 14- to 15-month-old infants (M = 14.99; range = 14.34–15.53 months) participated. An approximately equal distribution of the sexes was maintained across conditions. All infants were recruited through mailings to homes in the greater Chicago area, and the materials used were identical to those used in Study 1.

Materials and Procedure

The stimuli and apparatuses were identical to those used in Study 1. The procedure was modeled after Study 1, the only difference being in infants' condition assignment. Here, infants participated in either a name + hint or hint alone condition. Infants in the name + hint condition observed the experimenter label the first familiarization object and then demonstrate its function (e.g., "Look at these. This one is a *dax* and look what I can do with it."). In all other respects, these infants were treated identically to those in the novel name condition of Study 1. Thus, infants in the name + hint condition observed the function of only one familiarization object but heard all four objects labeled with the same name. The hint alone condition served as a control in which infants observed the function of the first familiarization object only. In all other respects, these infants were treated identically to those in the no-cue condition of Study 1 (e.g., "Look at these. Look what I can do with this one and look at this one.").

Coding

Coding was conducted as in Study 1. Clear choices were obtained on 95.8% of the trials. A primary coder scored all of the infants. A second coder independently scored eight infants, four per condition. Consistency was computed as the proportion of trials on which the coders agreed. Agreement was 100.0%.

Results

As predicted, our analysis of familiar category choices revealed that infants in the name + hint condition made more familiar category choices (M = 60%) than infants in the hint alone condition (M = 49%), one-tailed $t(22) = 1.77$, $p < .05$ (see Figure 3). Infants in the name + hint condition also made more familiar category choices than did those in the novel name condition of Study 1, $t(22) = 2.53$, $p < .025$.

We also evaluated the distributions of consistently familiar, consistently novel, and inconsistent responses across sets as in Study 1 (see Table 2). These analyses confirm the difference in performance detected in our parametric analysis. Infants in the name + hint condition made proportionately more consistently familiar category choices than did infants in the hint alone condition, $\chi^2(2, N = 24) = 6.81$, $p < .05$, or in the novel name condition of Study 1, $\chi^2(2, N = 24) = 13.38$, $p < .01$.

Discussion

After observing the function of one of four familiarization objects, infants who heard names for all four objects (name + hint condition) more readily detected category membership than did infants who observed the same single function in the absence of names (hint alone condition). Object names therefore can act as cues to categories for young infants as long as a core meaning is evident. In the name + hint condition, object function successfully provided this requisite core. Future research is necessary to specify whether other sources of core meaning are equally effective. For example, if infants have domain-specific knowledge about what features are important to attend to when classifying objects, then identifying novel objects as belonging to a particular domain may help infants to organize them into new categories (Booth & Waxman, 2002b; Jones & Smith, 1993).

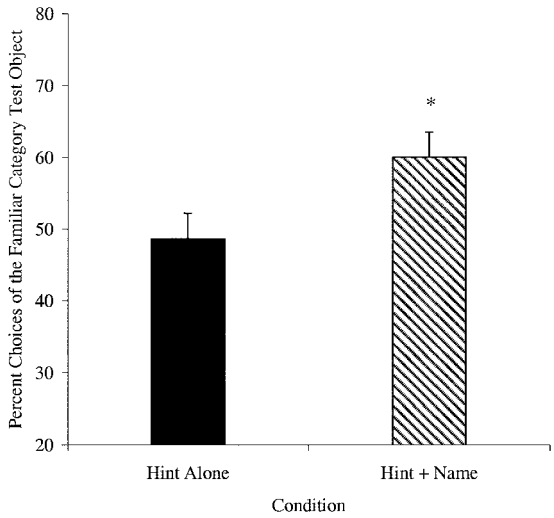

Figure 3. Percentage of 14-month-old infants' test object choices that corresponded to the familiar category in each condition of Study 2. Asterisk represents $p < .05$ versus the hint alone condition.

General Discussion

The goal of the current research was to explore potential contributions of object functions and object names to categorization in infancy. We pursued this goal by assessing infants' ability to form categories of novel objects in the presence and absence of these cues. Here, we review our conclusions regarding the effects of each cue, along with speculations regarding their underlying mechanism(s).

Object functions act as cues to categories. Observing the shared function of a series of novel objects facilitated categorization in infants at 14 and 18 months. But what is the mechanism by which object functions exert this effect? We consider two possibilities.

First, object functions might enhance infants' categorization in a general way by helping infants to identify a set of *objects* for comparison. Infants may devote particular attention to functioning objects because of their interest in the meaningful information that function conveys. When more than one object functions in the same way, infants may be motivated to compare these objects in search of any readily perceptible properties that will support predictions regarding the deeper, and often perceptually less obvious, functional information (Nelson, 1974, 1985).

Table 2
Number of Consistently Familiar, Inconsistent, and Consistently Novel Responses Made by 14-Month-Old Infants in Each Condition of Study 2

Condition	Consistently familiar	Inconsistent	Consistently novel
Hint alone	8	30	9
Name + hint	18	18	9

The results from both studies are consistent with such a mechanism. In Study 1, when four objects were shown to have the same function (novel function condition), infants were more likely to respond categorically to the perceptual commonalities among those objects than when no functional information was provided (no-cue and motion only conditions). Moreover, in Study 2, when the function of only a single familiarization object was provided (hint alone condition), infants failed to respond to these commonalities. Although the novel function and hint alone conditions were not matched in all relevant ways (e.g., sheer amount of time exposed to object functions), the difference between them suggests that identifying multiple objects for comparison on the basis of their common function may be important in facilitating categorization in young infants (see Eimas, Quinn, & Cowan, 1995; Greco, Hayne, & Rovee-Collier, 1990; Klibanoff & Waxman, 2000, for additional evidence relating to the importance of multiple exemplars in categorization).

It is also possible, however, that function enhances infants' categorization in a more directive way by helping infants to identify a subset of the *features* of objects on which to base their comparisons. To the extent that infants appreciate causal relations between functions and intrinsic object properties (e.g., shape or part structure), they may be able to focus specifically on those properties in forming new categories. Because those properties have critical relevance to core meanings, they are likely to be particularly diagnostic of category membership (Kemler Nelson, Frankenfield, Morris, & Blair, 2000). Therefore, a *feature*-identification mechanism could provide a very powerful tool.

The possibility that such a mechanism may be contributing to the facilitative effect of object function in the current work is supported generally by the fact that even very young infants appear to appreciate a limited range of causal relations between form and function (e.g., Bates, Carlson-Luden, & Bretherton, 1980; Brown, 1990; Hespos & Baillargeon, 2001). Although infants' depth and breadth of understanding clearly undergo substantial development from these early beginnings (Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Madole & Cohen, 1995; Madole et al., 1993), by 2 years of age infants show remarkable capacities for evaluating the plausibility of novel form–function relations and applying their causal understanding to forming new categories. Indeed, these relations become so compelling to children that they are able to support the extension of novel names even when only a single functioning object is labeled (Kemler Nelson, 1995, 1999; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000).

Despite the documentation of these impressive capabilities, we must have some indication of infants' ability to appreciate the specific causal relations between the appearance of our stimuli and their function in order to directly assess the plausibility of a *feature*-identification mechanism in the current work. Although our study was not specifically designed to evaluate this issue, comparing performance across stimulus sets may provide some insight. Adult ratings suggest that the stimulus sets varied systematically in terms of the transparency of the form–function relations they embodied. Eight adults rated Sets A and B as embodying a tighter link between object properties and function than Sets C and D. If a *feature*-identification mechanism were active, infants should have performed better on sets embodying more transparent form–function relations (Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000). The data reveal that both 14- and 18-month-old infants in the novel function condition of Study 1 chose the familiar category test object more frequently for Sets A and B ($M = 0.79$, $SD = 0.25$) than for Sets C and D ($M = 0.62$, $SD = 0.28$). However, it is important to note that facilitation was evident even for those sets in which form–function relations were not obvious. This is consistent with previous work with stimuli embodying arbitrary form–function relations (Booth, 2001) and suggests that both *feature*-identification and more general *object*-identification mechanisms are likely contributing to performance on the current task. Future work is clearly necessary to specify the mechanisms by which object functions facilitate categorization.

Object names act as cues to categories. Previous research has revealed that novel names facilitate categorization of familiar objects in infants (e.g., Waxman & Booth, 2001; Waxman & Markow, 1995). The current work goes further to document this effect with completely novel objects. Eighteen-month-old infants who heard novel familiarization objects labeled with the same novel noun were more likely to respond to the perceptual commonalities among objects from that category than were infants who did not. The current work also reveals a potentially powerful interaction between the effects of object functions and object names on categorization. Although 14-month-old infants benefited from the introduction of object names, they did so only when a core meaning for the novel objects was provided (in the form of the function of a single exemplar).

What mechanism(s) can account for these effects? Neither of the mechanisms we discussed in the context of object functions provides an adequate answer to this question. Although an *object*-identification mechanism is consistent with the behavior of our 18-month-old participants, it cannot account for the fact that names facilitated categorization in 14-month-olds only when a core meaning was evident. A *feature*-identification mechanism fares even worse, providing no feasible explanation for any of the data. The inadequacy of this alternative is related to a key difference between functions and names. Unlike object functions, names bear an arbitrary relation to the objects they denote. As a result, a name cannot provide a core meaning directly and cannot, in and of itself, focus infants' attention on features that may be diagnostic of this core. Any identification of specific features that occurs in the context of naming must be supported by an independent source of core meaning.

We offer the following as one possible explanation for the full developmental picture revealed in the current work. Early in lexical acquisition, infants focus attention on names for objects and devote particular attention to the link between objects and their

names for objects that they find interesting and relevant to their own activity (Fenson et al., 1994; Mervis, 1984; Nelson, 1974, 1979). These words are rich in meaning to infants and are therefore particularly useful to them in communicating about important aspects of their environment. A 14-month-old may therefore concentrate intently on learning the name for a single novel object with a clear core meaning (on the first familiarization trial in the name + hint condition of Study 2). When other objects are subsequently labeled with the newly acquired name, infants may assume that they share the same core meaning. To increase their chances of identifying additional members of the meaningful new kind, infants may search for other commonalities among the objects (i.e., aspects of their appearance) that are diagnostic of category membership. In contrast, if infants find no discernible core meaning associated with labeled objects (novel name condition of Study 1), they may be less captured by the naming episode and may therefore fail to learn the new word or to categorize the objects labeled by it.

Once infants acquire a sufficiently comprehensive lexicon (perhaps by 18 months of age), they may come to appreciate that names typically refer to deep commonalities among objects even when the core meanings of those categories are not immediately obvious (e.g., Davidson & Gelman, 1990). This general insight about naming may allow infants to use names as "essence placeholders" and to interpret novel names as referring to this essence even before they gain much specific information about it (Gelman & Coley, 1991; Gelman et al., 1994; Medin & Ortony, 1989). This possibility is consistent with recent evidence revealing that infants use names to categorize and to make inductive inferences regarding the nonobvious properties of objects before their second birthdays even in the absence of any perceptual support (Nazzi & Gopnik, 2001; Welder & Graham, 2001).

Older infants may also develop a better understanding of the causal relations that link intrinsic perceptible properties of objects to their core meanings (Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000; Madole & Cohen, 1995; Madole et al., 1993). As a result, they may be better able to infer the core meanings of objects without their demonstration and to determine which object features are likely to be most diagnostic of category membership. Such inferences could be based on general world knowledge (e.g., that parts often embody important object features; Rakison & Butterworth, 1998; Smith, Jones, & Landau, 1996; Tversky, 1989), or they could be evoked by the perception of affordances in the experimental context (e.g., infants might hypothesize that objects from Category A could be hung on the hook apparatus by their loops; Adolph, Eppler, & Gibson, 1993; Gibson, 1988). The development of such skills may allow object names to facilitate categorization in the absence of any hints regarding the core meaning of the labeled objects.

Regardless of the precise mechanism by which core meanings and object names interact to facilitate categorization, the fact that they do so at all in our young participants has strong implications for the ongoing debate over the contribution of conceptual information to early word learning. Previously, Landau, Smith, and Jones (1998; Smith et al., 1996) argued that word learning is driven by purely associative mechanisms that focus on perceptual information. They demonstrated several cases in which perceptual information (principally regarding object shape) appears to more strongly influence preschoolers' word extension than does conceptual information (as embodied in object functions; see also Gentner, 1978; Tomikawa & Dodd, 1980). Our research, however, joins a body of work providing evidence to the contrary (Kemler Nelson, 1995, 1999; Kemler Nelson, Frankenfield, Morris, & Blair, 2000; Kemler Nelson, Russell, Duke, & Jones, 2000). Kemler Nelson demonstrated that conceptual information (again, in the form of object functions) influences word extension in children as young as 2 years of age (see also Brown, 1990). The experiments reported here extend this finding to 14 months. Recall that in Study 2, we demonstrated that object function mediated the influence of naming on categorization. No new perceptual information was introduced here. Instead, the opportunity to glimpse the core meaning or conceptual substance of the stimuli made the crucial difference.

In conclusion, this research has identified two salient cues that facilitate categorization in infancy: object functions and object names. Perhaps more important, the work has begun to specify the possible mechanisms by which these cues help infants to partition their vast perceptual experiences into more manageable units. Future research is necessary to more fully explicate the details of these mechanisms, the conditions under which they are active, and the ways in which they interact with other contributors to categorization (e.g., basic processes of comparison and evaluation of similarity).

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