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The Influence of Gestures and Object Labels on Infants' Inductive Inferences

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "The Influence of Gestures and Object Labels on Infants' Inductive Inferences" submitted by Cari S. Kilbreath in partial fulfillment of the requirements for the degree of Master of Science.

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Abstract

The purpose of the present experiments was to examine the influence of gestures and object labels on infants' inductive inferences about nonobvious object properties. In two experiments, infants were presented with novel target objects with or without nonobvious properties, followed by test objects that varied in shape similarity to the target objects. At 14 months, infants relied on shape similarity and shared gestural and verbal labels to guide their inferences about object properties. At 22 months, infants relied on shape similarity to guide their inferences when provided with shared gestures or no labels for objects. However, when provided with shared verbal labels, infants relied solely on the name to guide their inferences about object properties. These results demonstrate a developmental narrowing in the types of symbols infants will accept as markers of object categories as well as the powerful role of shape similarity and shared labels in guiding infants' inferences.

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INTRODUCTION

Categorization of objects involves a grouping together of distinct objects into classes using certain criteria or rules. Children (and people in general) can demonstrate their categorization abilities in a number of ways, such as grouping objects together, treating them similarly, or giving them the same name (Oakes & Rakison, 2003). There are several general areas of debate existing in the field of children's categorization that have been the focus of much research in recent years. One such issue concerns the type of information that guides children's categorization. Some researchers argue that children focus primarily on perceptual information gained from the physical appearance of objects (e.g., shape and parts) when forming categories (e.g., Jones & Smith, 1993; Quinn & Eimas, 2000; Quinn & Johnson, 2000; Rakison, 2000; Younger & Fearing, 2000). In contrast, others argue that even young infants form categories based on conceptual information (e.g., Carey, 2000; Gelman, 2003; Mandler, 1998; 1999; 2000a; 2000b; 2000c; Mandler & McDonough, 1996; 1998; Xu, Carey, & Welch, 1999), which describes the kind of thing an object is or conveys information about the underlying nature of objects. This issue is all the more contentious due to the fact that perceptual and conceptual information is often difficult to distinguish. For example, although object shape is often thought to reflect perceptual information, some researchers argue that an object's shape is actually indicative of the *kind* of thing it is. That is, it has been argued that since an object's underlying nature or kind is often associated with and predictive of its observable properties, such as object shape, findings that children are relying on perceptual information to form their categories may actually indicate a reliance on conceptual information instead (see Gelman, 2003 for a discussion).

Somewhat related to the perceptual-conceptual debate is the issue of the role of theories in children's categorization. This debate lies between researchers taking the stance that children rely on theories in their formation of categories and those with the opinion that children form categories due to "dumb attentional mechanisms" (see Gelman, 2003 and Oakes & Rakison, 2003 for discussions). The view that holds that children rely on theories in their categorization suggests that perceptual features are not always accurate in determining category membership, but hidden, nonobvious properties usually are. Thus, proponents of this view (e.g., Carey, 1985; Gelman, 2003; Gelman & Koenig, 2003; Gopnik & Nazzi, 2003; Gopnik & Wellman, 1994; Wellman & Gelman, 1988) would suggest that children's categorization is influenced by their theories and inferences about the nonobvious properties of category members. For example, children may have certain theories that objects with the same function are the same kinds of things, leading them to place objects with the same function in the same category. In contrast, the view that holds that children's categorization is due to a "dumb attentional mechanism" suggests that children categorize objects through a simple associative learning mechanism (e.g., Smith, Jones, & Landau, 1996). Thus, rather than having theories that guide the formation of their categories, it is argued that children attend merely to common salient perceptual features and other contextual information (e.g., repeated linguistic contexts, such as "This is a _____".) to guide their categorical decisions.

Another issue of debate in the area concerns the role of language in children's categorization. The issue here concerns the importance of language in influencing children's conceptual representations (see Gelman, 2003 and Oakes & Rakison, 2003 for discussions). One side of this debate argues that language is not necessary for children's categorization, one reason being that prelinguistic infants can form categories. However, the other side of this debate points out that while language may not be necessary for categorization, there does seem to be some relationship between them. Infants do seem to treat labeled and nonlabeled objects differently, grouping together objects that are labeled with the same name, even when the objects may not perceptually appear as if they belong to the same category (e.g., Gelman & Coley, 1990; Graham, Kilbreath, & Welder, 2001; under review). Gelman (2003) also discusses another reason why language is important for categorization: providing a name for an object unambiguously denotes what category it belongs to. This information cannot always be gained without language, especially when objects do not perceptually look similar.

These issues are still matters of on-going debate in the categorization literature, and most likely will remain that way for some time. Because these are such controversial debates, a great deal of research has been done examining these types of issues using a variety of methods. Recall that categorization is evidenced in a number of ways, by grouping objects together in some way, treating them similarly, or giving them the same name, which gives rise to numerous ways in which to examine it (see Oakes & Rakison, 2003 for a detailed discussion of these methods). One method used to examine children's categorization is termed sequential touching. In this procedure children are given objects from two different categories and their touching of those objects is measured. Sequential touching of objects is taken to reflect children's view that those objects belong to the same category. A second type of procedure used is name generalization tasks. In these tasks, children are taught a name of one object and are then shown other objects and asked whether they share the same name as the first object. When children indicate that two objects share the same name, it is assumed that they believe those objects belong to the same category. Another way in which children's categorization is often measured is through habituation procedures. In these tasks, children are first familiarized with several objects from the same category. Then children are either presented with test objects that belong to the same category or a different category from the familiarization objects. Children's looking time is assessed as a measure of whether they view the test objects as belonging to the same category as the familiarization objects. That is, since children should have habituated to the category of objects in the familiarization phase, they should be quite interested in and look longer at objects belonging to a different category, but not at objects belonging to the same category.

A final approach (which is used in the present studies) to examine children's categorization is through children's inductive inferences. Inductive reasoning involves assuming that something that is true for one member of a category will also be true for other members of the same category (Moore & Parker, 1989). For example, a child may learn that a particular ball bounces and then make the inference that another ball can also bounce as it is a member of the same category. The ability to reason inductively is important, as it allows for generalization of knowledge to new instances and situations. That is, once children have learned something about one member of a category, they can generalize that knowledge to other members of the same category without any relearning.

Preschoolers' Inductive Abilities

Early investigations of young children's inductive abilities suggested that preschoolers were limited to reasoning on the basis of perceptually-based categories and were unable to appreciate the inductive power of complex categories (see Mandler, 1998; Wellman & Gelman, 1988 for reviews). However, more recent research has demonstrated that by 2-1/2-years of age, preschoolers possess remarkably sophisticated inductive abilities. In a typical inductive inference task with preschoolers, an experimenter will first teach children about a nonobvious property (a property of the object that is not visually accessible to the child) of a target object. Children are then shown various test objects and asked if these objects share the same property as the target object. Using this inductive generalization paradigm, studies have demonstrated that preschoolers have well-developed inductive abilities (e.g., Gelman & Markman, 1986, 1987; Kalish & Gelman, 1992). For example, Gelman and Coley (1990) found that 2-1/2-year-old children can rely on either perceptual or conceptual information to guide their inductive generalizations about object properties. These researchers taught 2-1/2-year-olds a property (e.g., "lives in a nest") of a target pictured object (e.g., bluebird). Then children were shown four test pictures: a typical member (e.g., bluebird) and an atypical member (e.g., dodo) of the target category and a typical and atypical member of a different category (e.g., with a category of dinosaurs, stegosaurus and pterodactyl, respectively). The pictures were either labeled with the category label (e.g., "This is a bird.") or not labeled. After viewing each test picture, children were asked whether the property that was true of the target object was also true for that object (e.g., "Does it also live in a nest?"). The results indicated that when children were provided with category labels, they relied on category membership to generalize the property and overlooked perceptual similarity. That is, when they learned that a bluebird lives in a nest, children generalized that property to a dodo bird, which belongs to the same category but is perceptually dissimilar to the target bird. Furthermore, children did not generalize the properties to objects that were perceptually similar (e.g., pterodactyl) to the target object when these objects were from a different category. In the absence of category labels, children relied on perceptual similarity to guide their inferences. That is, children generalized the target property to test objects (e.g., pterodactyl) that shared perceptual similarity with the target object (e.g., bluebird), regardless of category membership.

Other induction studies with preschoolers have revealed several additional findings regarding their inductive abilities (see Gelman, 2003 for a discussion). First, while preschoolers can rely on shared category labels to guide their inferences even when objects are dissimilar in appearance, they do not seem to do so as the result of a response bias due to hearing the same word used for two objects. For instance, children will still rely on shared names to guide their inferences when objects are labeled with synonymous names (e.g., rock and stone) rather than with identical names (Gelman & Markman, 1986). These findings suggest that children are actually using the labels as cues to category membership and using that information to guide their inferences. Second, preschoolers also seem to be able to make category-based inductive inferences without the presence of shared labels. Gelman and Markman (1987) found that when objects were not labeled, children drew more inferences to an object from the same category as a target object than to a distinct out-of-category object that shared more perceptual similarity to the target than the in-category member. Thus, preschoolers would draw inferences from a leaf insect to a black beetle more often than from a leaf insect to a leaf. It seems that children in this study were able to determine category membership based on subtle perceptual features, such as the presence of a head and eyes, thus realizing that the leaf insect and the black beetle were both bugs, even though they did not look similar to each other. Finally, preschoolers will also limit the inferences they make based on factors such as previous knowledge about a particular category, property generalizability, and category homogeneity (Gelman, 1988). For example, preschoolers will not draw inferences about shared properties when two objects are labeled with a term that describes a transient state rather than with a term that is a category label (e.g., "This is *sleepy*" as opposed to "This is a *bird*"; e.g., Gelman & Coley, 1990). Preschoolers will also attend to the nature of the property to be generalized and will not generalize those properties that are arbitrary (e.g., "fell on the floor this morning") beyond the target exemplar (e.g., Gelman, 1988). Thus, findings of studies of preschoolers' inductive abilities indicate not only that young children have very sophisticated reasoning abilities, but also that they are in fact able to use conceptual information to guide their inferences.

Infants' Inductive Abilities

Researchers have recently begun to examine whether infants can also reason inductively and what types of information might guide their inductions. One of the challenges in this research area lies in finding an appropriate paradigm to examine infants' reasoning abilities, as traditional inductive generalization tasks that rely on verbal responses are not appropriate for infants. In response to this issue, researchers have adapted the generalized imitation paradigm to examine infants' inductive reasoning abilities. In this paradigm, an experimenter will first model an action on a target object that invokes some hidden property of the object. Then test objects, which are related or unrelated to the target object, are given to the infants and they are observed to see whether they imitate the target action on the various test objects. If the infants do imitate on the test objects, then it is assumed that they perceive those objects as belonging to the same category. Thus, their imitation demonstrates that they expect the test objects to share the same hidden properties as the target object.

Research on infants' inductive reasoning abilities using imitation paradigms has demonstrated that infants as young as 9 months of age possess basic inductive reasoning abilities. Using a generalized imitation paradigm, Baldwin, Markman, and Melartin (1993) examined the inductive abilities of 9- to 16-month-old infants. In three within-subjects conditions, infants were presented with novel target objects (e.g., a horn) with nonobvious properties that could be invoked using particular actions (e.g., honked when squeezed), and were allowed to explore these objects. In the violated expectation condition, the target object was functional but the test objects were disabled such that they were incapable of producing the nonobvious property. In the interest control (baseline) condition, both the target and test objects were disabled and thus, incapable of producing the nonobvious property. In the fulfilled expectation condition, both the target and test objects were capable of producing the nonobvious property. Baldwin et al. found that infants performed significantly more target actions on test objects in the violated expectation condition than in the interest control condition, signifying that they expected the test objects to possess the same properties as the target object. In a second experiment, infants performed significantly more target actions on perceptually similar test objects (e.g., horns that differed only in color and pattern from the test object) than on perceptually different test objects, in the violated condition. These results indicate that infants as young as 9 months of age are capable of making inductive inferences after just a brief exposure to a novel object, and that they use perceptual information to guide their inferences.

Other research has focused on the nature of the categories that guide infants' inductive generalizations. Studies have demonstrated that infants can use conceptual information to guide their inductive inferences. In a series of studies, Mandler and McDonough (1996) modeled actions for 14-month-olds that were either appropriate for the category of object (e.g., a dog sleeping on a bed) or inappropriate (e.g., a car sleeping on a bed) for the category of object (e.g., animals or vehicles). Infants were then presented with test objects from the same category and distracter objects from the other category. Mandler and McDonough found that 14-month-old infants would only generalize appropriate actions to members of the same category as the target object. For example, when shown a dog sleeping on a bed, infants would make another animal (e.g., a cat) but not a vehicle, sleep on a bed. Moreover, infants would generalize the property to a member of the same category even when the objects were dissimilar in appearance (e.g., a dog and a fish). Finally, infants did not generalize properties to exemplars from different categories, even when those exemplars were perceptually similar to one another (e.g., a bird and an airplane). These results indicate that with familiar categories of objects like animals and vehicles, 14-month-olds can rely on their previous conceptual knowledge about object kind to guide their inductive inferences.

Research has also demonstrated that infants can use conceptual information provided on-line to guide their inductive inferences. In a recent study, Welder and Graham (2001) examined 18-month-old infants' reliance on perceptual and conceptual information to guide their inferences about novel object properties. In a series of studies, infants were presented with novel target objects that had nonobvious properties (e.g., made a ringing sound when tapped) followed by test objects that varied in degree of shape similarity to the target. Infants saw these objects in three within-subjects conditions: a surprised condition (target functional, test objects nonfunctional), an interest control condition (target and test objects nonfunctional), and a predicted condition (target and test objects functional). In Experiments 1 and 2, for one group of infants, the target and test objects were labeled with novel count nouns (e.g., "Look at this flum!"). For another group of infants, no labels were provided for the target or test objects; rather the infant's attention was just drawn to the object (e.g., "Look at this one!"). In Experiment 3, the target and test objects were labeled with the same familiar count noun (e.g., "Look at this ball!"). When infants were not provided with object labels, they performed significantly more target actions on high similarity test objects than on medium similarity, low similarity, or dissimilar test objects, indicating that they were relying on high shape similarity to guide their inductive inferences. When infants were provided with object labels, the influence of shape similarity was either reduced (with novel labels) or eliminated (with familiar labels). The results of this study indicate that 18-month-old infants recognize that objects that share the same label belong to the same category, and therefore share similar properties.

In a similar design to that used by Welder and Graham (2001), Graham et al. (2001; under review) examined the inductive abilities of 12-month-old infants who are just beginning to develop productive language. The infants were tested in one of two between-subjects groups: in the Novel Label group, the target and test objects were labeled with the same novel label (e.g., "Look at this flum!"). In the No Label group, no labels were provided for any of the objects (e.g., "Look at this one!"). Consistent with Welder and Graham's results with 18-month-olds, infants in the No Label group relied on shared shape similarity to guide their expectations about shared object properties. That is, infants performed more actions on test objects that were highly similar in shape to the target object than those that were low in similarity. Infants in the Novel Label group relied on the object labels to generalize the nonobvious properties. That is, these infants performed a similar number of actions on test objects that were both high and low in shape similarity to the target object. Therefore, 12-month-old infants, like 18-month-olds, understood that objects with the same label belonged to the same kind, and thus expected them to share similar properties. These results indicate that infants who are just beginning to use productive language appreciate that words carry information about category membership, and that these words can be used to guide their inductive reasoning.

The Role of Naming in Categorization

Research demonstrating that preschoolers and infants can use labels to guide their inductive inferences is consistent with a growing body of evidence demonstrating the powerful role of naming in the formation of young children's categories. Several recent empirical studies have found that naming can promote infants' formation of object categories (e.g., Balaban & Waxman, 1997; Graham, Baker, & Poulin-Dubois, 1998; Waxman, 1999a, 1999b, Waxman & Hall, 1993). For example, Xu (2002) demonstrated that while 9-month-old infants expect two distinct names to refer to two distinct objects, they do not expect two distinct tones or emotional expressions (e.g. "Ah" and "Ewy") to refer to two distinct objects. In addition, Waxman and Markow (1995) found that words facilitated 12- to 13-month-olds' categorization at the superordinate level (e.g., animals vs. vehicles), even when objects from the same category were dissimilar in appearance. Fulkerson and Haaf (2003) further demonstrated that labeling phrases (e.g., "Look at the toma") are privileged over both non-labeling sounds (e.g., "sa sa sa sasa") and no sounds in guiding 9-and 15-month olds' superordinate level categorization. More recently, findings from a study by Booth and Waxman (2003) indicate that by 14 months of age, infants are even sensitive to the grammatical forms of words when determining whether two objects belong to the same kind category, and thus only expect objects labeled with the same count noun (and not with the same adjective) to belong to the same category. Furthermore, infants in this study extended novel adjectives to object properties, such as color, and not to object categories. In sum, a large body of research demonstrates that naming can play a facilitative role in infants' category formation.

There are a number of possible explanations for the facilitative effect of naming on object categorization. First, it is conceivable that labeling itself increases infants' attention to objects, and this increased attention is what then facilitates their categorization. That is, naming could lead infants to examine objects more closely, leading them to detect commonalities (e.g., perceptual features) between objects, which in turn could help infants to form a category of objects (Fulkerson & Haaf, 2003; Xu, 2002). While it has been demonstrated that labeling objects seems to increase infants' attention to these objects relative to when objects are not labeled (e.g., Xu, 2002), several recent experiments with varying tasks and procedures have found that this is an unlikely explanation for their facilitative effect in object categorization (e.g., Balaban & Waxman, 1997; Graham et al., under review, Xu, 2002). For example, Graham et al. (Expt.3) (under review) provided 12-month-old infants with either similar or different count noun labels for target and test objects using an imitation paradigm. Infants were shown a property of a target object that could be invoked with a particular target action while it was labeled with one count noun (e.g., "Look at this flum."). They were then presented with a test object that was labeled with either the same count noun label (e.g., "Look at this flum.") or a different count noun label (e.g., "Look at this gop."). The frequency of their performance of target actions on test objects was measured. Results indicated that infants generalized object properties to objects both high and low in shape similarity when the objects were introduced with the same name as the target object. However, they only generalized object properties to objects that were high in shape similarity when target and test objects were introduced with different labels. If infants were simply making their categorization decisions due to increased attention to the objects (provided by the presence of labels), they should behave similarly whether objects were labeled with the same names or with different names.

Second, it is possible that it is something specific about labels in particular that drives categorization of objects. That is, infants may have an implicit understanding that words, and particularly count nouns, map onto specific object kind categories and this understanding is what facilitates object categorization (see Booth & Waxman, 2003; Waxman, 1999a). In support of this explanation, studies have demonstrated that the facilitative effect of naming on object categorization can be restricted to count noun labels. That is, by 13 months of age, infants appear to understand that count noun phrases label object kind categories rather than other "superficial" properties such as color, which is highlighted by adjective phrases (e.g., Booth and Waxman, 2003;

Waxman, 1999a; Waxman & Booth, 2001). Waxman (2003) suggests that there are two possibilities as to how this noun-category linkage comes to exist. First, it is possible that this linkage exists innately. Evidence supporting this proposition comes from the fact that nouns are used across languages to denote category membership of objects. Secondly, it is possible that this noun-category linkage is learned. Evidence supporting this proposition comes from the observation that nouns are the most common forms of words in infants' early vocabularies. Waxman suggests that since nouns tend to denote category membership, it may be that infants learn this noun-category association because they have such a high proportion of nouns in their vocabulary.

One question that remains unanswered is whether linguistic stimuli, as opposed to nonlinguistic stimuli, are privileged in guiding infants' inferences about object properties. This is an important question as the answer will help determine whether words are indeed special in guiding infants' inferences, or whether other forms can also be used by infants in the same manner as words. Certainly there are some similarities between verbal labels and nonlinguistic stimuli such as gestures. Both names and gestures are used to communicate about objects and events in the world, and can be used in a similar fashion to represent those things. That is, both names and gestures are symbolic forms that can be used to "label" objects or categories.

Recent research indicates that young infants will treat some nonlinguistic information as naming object categories. Woodward and Hoyne (1999) introduced 13-month-old infants to novel objects using either a novel word or sound (e.g., "Look at this. (word/beep).") In this study, infants played a game in which they took various novel objects out of a bucket. Once the experimenter had established joint attention on the target object with the infant, the novel words or sounds were introduced. Distracter objects were also introduced; however, these objects were not labeled at all, but rather the infant's attention was drawn to the objects in order to familiarize them with the objects. After this initial training, a multiple choice procedure was used to see whether infants would choose target objects that were either exactly the same or different in color from the ones presented during the training from amongst the distracter objects. In the word condition, infants were asked, "Can you get the (novel word)?", while in the sound condition they were asked, " Can you get one of these?", after which the novel sound was produced. Infants learned both word-object and sound-object associations, as they chose the target object in both the word and sound conditions at greater than chance levels. Interestingly, a second study not only replicated the findings from the sound condition for 13-month-olds (i.e., they learned sound-object associations), but also demonstrated that 20-month-olds did not learn these same sound-object associations, suggesting that only younger infants will accept these types of nonlinguistic information as naming object categories.

Namy (2001) also demonstrated that infants will also accept other symbolic forms as object names. In this study, 17-month-old infants were first introduced to familiar objects along with novel symbols (either novel words, gestures, sounds, or pictograms) as names for them. During the test phase, a forced-choice categorization task was implemented, in which infants had to choose between test objects from the same superordinate category (e.g., fruit or animals) as the target object and distracter objects. Infants were asked, "Can you find another (symbol), and were presented with either the same novel word, gesture, sound, or pictogram as they had with the target object. Results indicated that infants mapped all of the novel symbols to the appropriate test objects (i.e., those from the same category as the target) at greater than chance levels (one exception was the sound condition in which infants were just marginally better than chance). Furthermore, when their performance in the other symbol conditions was compared to their performance in the word condition, no differences were found. Thus, this research suggests that infants can indeed interpret other symbolic forms as object names, and at 17-months of age, do not seem to have a preference for words as compared to other symbolic forms.

While young infants seem to accept a wide range of symbolic forms (both verbal and nonverbal) as names for object categories, there appears to be a point in their development when they no longer accept nonverbal forms of symbolic reference as object names. As previously discussed, Woodward and Hoyne (1999) found that while 13-month-olds would make sound-object associations, 20-month-olds would not. Namy and Waxman (1998), using a similar design to that used in Namy (2001), compared the performance of 18- and 26-month-old infants on a forced-choice categorization task. Both 18- and 26-month-olds interpreted novel words as object names, as they chose test objects from the same category as the target when they were called by the same novel name. However, when novel gestures were presented with both the target and test objects, only the 18-month-olds interpreted the gestures as object names. In contrast, the 26-month-old infants did not choose test objects from the same category as the target at greater than chance levels when they were presented with the same gesture. The authors suggested that while younger infants may be able to interpret both words and gestures as names for object categories, older infants may develop a preference for words in naming object categories because of their greater experience with words being used in this manner as compared to gestures.

Namy and Waxman (2002) further examined this developmental change in infants' acceptance of gestures as object names. In this study (which used the same procedure as the Namy and Waxman (1998) study), these researchers examined infants' production of novel gestures and novel words after having been exposed to them in the course of a play session. They found that 26-month-old infants produced both novel gestures and novel words equally (and to a much higher degree than 18-month-olds). However, the 26-month-olds produced the words in a referential manner whereas they did not produce the gestures in a referential manner. Rather, they seemed to imitate the experimenter, without reference to particular objects. Thus, it may be that older infants no longer use or comprehend gestures as referential symbols and thus, do not accept them as naming object categories.

Namy, Acredolo, & Goodwyn (2000) reported on studies investigating parental input of both words and gestures to their young infants in a free-play session. These researchers found that while parents more frequently used words to refer to objects, their use of gestures was also significant and actually predicted their children's use of gestures as well. The authors suggest that this potentially explains why younger infants will accept both symbolic forms to refer to objects while older infants will not. That is, it seems that younger infants are exposed to both symbolic forms early in development, and they are able to realize that both symbolic forms can refer to object names. However, it may be that when infants become more experienced and more able to use words to refer to objects, their parents may decrease and eventually eliminate their use of gestures to refer to objects. Infants would thus have no reason to focus on this information as referring to particular objects after they develop more fluency with words. On the other hand, it may be that it is not parental input that is driving this developmental change, but rather something within infants themselves that changes over the course of development. That is, perhaps older infants can focus their attention on learning the symbols that are most commonly used in their environment (i.e., words), whereas younger infants do not do this yet, and thus learn various symbols, whether they are commonly used or not.

The Present Studies

The overall goal of the present studies was to examine whether linguistic stimuli, as opposed to nonlinguistic stimuli, were privileged in guiding infants' inferences about nonobvious object properties. More specifically, the first goal was to examine whether infants will rely on shared gestural labels, as they do shared verbal labels, to guide their inductive inferences about object properties. Thus, the performance of infants was compared when they were provided with shared gestures, shared names, and no labels. Although previous research has demonstrated that infants as young as 12-months of age will use shared object labels to guide their inferences about nonobvious object properties (Graham et al., 2001), and that young infants will accept a wide variety of nonverbal symbolic forms as names for object categories (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999), it remains unclear whether infants will use these nonverbal symbolic forms to guide their inferences about object <u>properties</u>. A second purpose of the present studies was to examine developmental differences in infants' ability to use this nonverbal symbolic information to guide their inductive inferences about object properties. Thus, the performance of 14-month-old infants was compared to the performance of 22-month-old infants across two experiments.

A generalized imitation paradigm was used in both experiments. The experimenter first presented infants with novel target objects that possessed nonobvious sound properties, and demonstrated how these properties could be invoked with a particular target action. The target objects were introduced with either a novel gesture, a novel name, or no label. Then infants were presented with test objects that varied systematically in degree of shape similarity (high similarity, low similarity, and dissimilar) to the target object, accompanied by the same gesture, name, or no label. Past research indicates that when categorizing objects, infants and preschoolers attend to object shape over other perceptual information (such as color and size) (e.g., Baldwin, 1989; Graham & Poulin-Dubois, 1999; Landau, Smith, & Jones, 1988; 1992; Smith, Jones, & Landau, 1992), thus the focus was on shape similarity within the object categories in the present study (as opposed to other types of perceptual similarity). If infants consider the target and test object to belong to the same object kind or category, they should also expect them to share similar properties, and thus generalize the target action to the test object. The high similarity objects within each set varied only in color from the target objects, while the low similarity objects within each set varied in shape and color. The dissimilar objects in each set, however, differed from the target object in texture, shape, and color. The dissimilar objects were included to ensure that infants' inductive generalizations were specific to objects that they perceived as belonging to the same category and to assess the possibility that participants were merely imitating the experimenter's actions on any object, regardless of whether an expectation was generated.

Infants were presented with object sets in three within-subjects conditions. In the predicted condition, both the target and test objects possessed the same nonobvious property, which could be elicited by a particular target action (e.g., both rattle when shaken). This condition was included merely to ensure that infants did not get frustrated or bored if they realized that all the test objects were not functional. In the baseline condition, neither the target nor the test objects possessed the nonobvious property (e.g., neither rattle when shaken). In the surprised condition, the target object possessed a nonobvious property that could be elicited by a particular target action (e.g., rattled when shaken), but the test objects were disabled so they were incapable of producing the same property. This was the particular condition of interest, as it allows us to assess infants' expectations about shared properties. If infants view two objects as belonging to the same category and thus, expect them to share the same properties, they should persist in trying the target actions in order to invoke the same properties. A comparison of infants' performance in this condition to the baseline condition will ensure that the properties of the objects are indeed nonobvious. Thus, if infants only perform target actions on test objects when those actions are demonstrated for them (as in the surprised condition), then it can be assumed that the properties of the objects were nonobvious.

EXPERIMENT 1

The purpose of Experiment 1 was to examine whether 14-month-old infants will rely on either shared object labels or shared gestures to guide their inferences about nonobvious object properties. Given the findings of recent studies (i.e., Namy, 2001;

Namy & Waxman, 1998; 2002; Woodward & Hoyne, 1999), it was expected that 14-month-old infants would recognize that objects introduced with the same name or the same gesture belong to the same object category, and thus share a nonobvious property. Thus, it was predicted that 14-month-olds in the surprised condition would generalize a nonobvious property to objects that shared the same name or the same gesture, even if they shared only minimal perceptual similarity with the target object. However, for infants not provided with labels of any kind (no label group), it was predicted that they would rely on shared shape similarity to guide their inferences. More specifically, it was hypothesized that infants in the surprised condition would perform more target actions on test objects that were closer in shape similarity to the target object than on test objects that were less similar in shape. For all three of the groups, it was expected that if infants perceived the dissimilar objects as clear out-of-category objects they should not imitate the target actions on these objects in the surprised condition.

Method

Participants

Data from 69 14- to 15.5-month old infants were included in this study, with 23 infants assigned to each between-subject group (gesture condition, name condition, or no label condition). In the gesture condition, there were 12 males and 11 females with a mean age of 14.86 months (SD = .43; range: 14.07 to 15.49 months). In the name condition, there were 13 males and 10 females with a mean age of 14.84 months (SD = .34; range: 14.03 to 15.39 months). Finally, in the no label condition, there were 10 males and 13 females with a mean age of 14.80 months (SD = .37; range: 13.98 to 15.43 months). An additional twenty-six infants were tested, but were excluded from the final sample for the following reasons: excessive fussiness (n = 13), parental interference (n = 4), experimenter error (n = 2), and statistical outliers (n = 7; see Data Reduction section). The infants were recruited through advertisements in health clinics as well as in local newspapers. All of the infants were given a t-shirt, a small toy, and a Child Scientist certificate for their participation. Ethical approval was obtained from the University of Calgary Conjoint Faculties Research Ethics Board. Informed consent was obtained from parents before beginning the testing session, and parents were also informed that they were free to withdraw from the study at any time.

Materials and Equipment

Four objects were used in the warm-up phase: a garlic press, a clicking clock, a roller ball, and a clothesline pulley.

Three object sets were constructed for use in the testing phase: a rattling set, a ringing set, and a squeaking set. Each set consisted of a target object and three test objects: a high similarity object, a low similarity object, and a dissimilar object (see Figures 1, 2, and 3). The high similarity objects were similar in shape and texture to the target object, but different in color. The low similarity objects were similar in texture to the target object, but different in shape and color. The dissimilar objects differed in shape, texture, and color when compared to the target object. To establish whether test objects could reliably be categorized as high or low in shape similarity relative to the target object, 15 adult judges (9 females and 6 males, all over age 18) rated the similarity of each test object to its target. The rating scale ranged from 1 (*not at all similar*) to 7 (*very similar*). The adult ratings followed the expected pattern in that the high and low similarity test objects in each object set were perceived as significantly different in shape

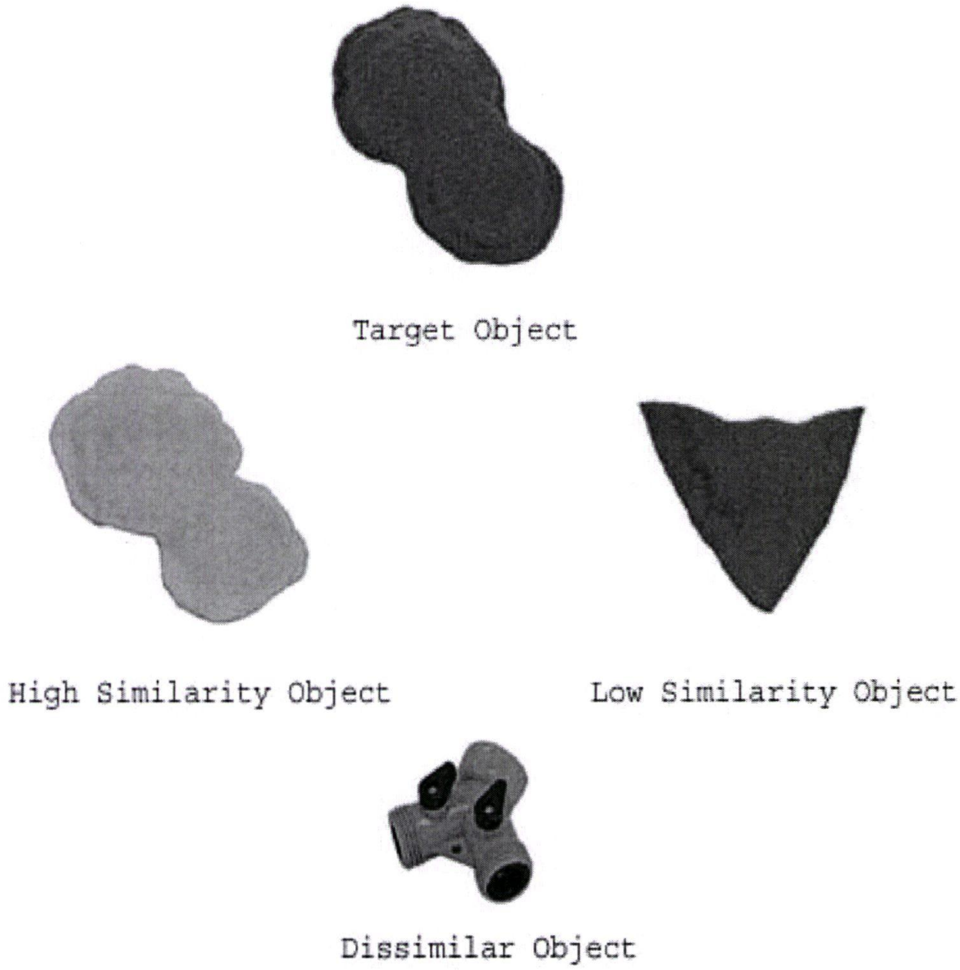


Figure 1. Rattling set.

Figure 2. Ringing set.

Figure 3. Squeaking set.

from one another (all t tests: $p < .05$), in the direction intended. The dissimilar objects were a green hose splitter (rattling set), a plastic red file (squeaking set), and a small white strainer (ringing set).

A functional and nonfunctional version of each set was created. For the functional version, each object was capable of producing the nonobvious target property. For the nonfunctional version, the objects were disabled so that they were incapable of producing the target property. Note that the dissimilar object was always nonfunctional. For the rattling set, 7 cm (rattle portion) by 4 cm (handle portion) rattles were covered with felt and shaped in various ways with sponge, or by removing portions of the rattle frame. The functional version of the rattling set produced a rattling sound when shaken. For the ringing set, a metal bell with a button on the top that was connected to a ringer inside was placed inside a styrofoam shape and covered with faux-fur material. The functional version of the ringing set produced a ringing sound when tapped. For the squeaking set, hollow rubber balls (7 cm in diameter) were covered with pleated rayon and shaped in various ways with string and/or sponge. The functional version of the squeaking set produced a squeaking sound when squeezed.

The MacArthur Communicative Development Inventory: Infants Version (MCDI; Fenson et al., 1991), a parent questionnaire, was used to assess the infants' productive vocabulary in order to equate the groups on productive vocabulary size. Infants' productive vocabulary size ranged from 3 to 102 words ($M = 21.95$ words, $SD = 28.78$) in the gesture condition, 0 to 272 words ($M = 37.30$ words, $SD = 64.80$) in the name condition, and 0 to 188 words ($M = 25.59$ words, $SD = 41.74$) in the no label condition. There were no differences in infants' productive vocabulary size between the name and gesture conditions, t (39) = 0.99, $p > .05$, the gesture and no label conditions, t (41) = 0.33, $p > .05$, or the name and no label conditions, t (40) = 0.70, $p > .05$.

Parents were also asked on the consent form whether or not they used signs or gestures at home with their children. Because there is a recent trend for parents to teach their infants signs for objects, it was important to examine any influence of having previous experience using signs. Of the 23 infants in the gesture condition, parents reported 11 of them to have previous experience using signs. In each of the name and no label conditions, 7 out of 23 infants were reported to have previous experience using signs.

All sessions were videotaped for coding purposes with a Sony video camera, which was placed behind a one-way mirror. Trials in each session were timed with a handheld stopwatch.

Design

Each infant was randomly assigned to either the gesture condition, the name condition, or the no label condition (see Table 1 for a listing of the gestures and novel labels used). For each infant, one of the three object sets was presented in the surprised condition, one set was presented in the baseline condition, and one set was presented in the predicted condition. The specific object set assigned to each condition was counterbalanced across infants.

The testing phase consisted of three blocks of three trials each: one trial in the surprised condition, one in the predicted condition, and one in the baseline condition. Each object set was presented once within each block. Therefore, one of the test objects (e.g., a high similarity object) from a given set was presented in the first block, another

Table 1

Novel gestures and labels used with each object set.

Object Set	Label	Gesture
Rattling set	fep	All five fingers extend up and out from closed fist
Ringing set	zav	Hand moves from left, where hand is open and fingers are extended, to the right, where fingers are closed together
Squeaking set	wug	Thumb, pointer, and index finger extend out horizontally from closed fist

(e.g., a low similarity object) was presented in the second block, and a third (e.g., a dissimilar object) was presented in the third block (see Table 2 for an example). The order of presentation of test objects (high similarity, low similarity, and dissimilar) was randomized within each block. Also, the order of presentation of the within-subjects conditions (surprised, baseline, and predicted) was randomized across infants. This order was then fixed for each infant within each block.

Procedure

During the testing session, the infant was seated in their parent's lap, across a table from the experimenter. Before the testing session began, parents were instructed not to prompt, cue, or direct their infants in any way during the session. They were told that they could repeat their infant's name, if he or she became fussy. They were also instructed to place objects on the table in front of their infant, if their infant dropped an object off the table during the session, or if he or she passed it to the parent.

In the warm-up phase, the experimenter first demonstrated a target action on each of the warm-up objects. Then the object was handed to the parent who demonstrated the same actions for the infants. The parent then handed the object to the infant so that he or she could imitate the demonstrated actions. The warm-up trials were included to demonstrate to the infants that they were to imitate the experimenter's actions when appropriate, and to help the infants feel more comfortable in the testing situation. After the warm-up phase, all participants proceeded to the testing phase, regardless of whether or not they imitated the target actions.

Each trial in the testing phase began with the presentation of the target object. The experimenter first introduced the object, and then demonstrated the target property

Table 2

An example of the testing phase in Experiments 1 and 2

Block 1	Trial 1. Surprised condition (ringing set[a] – high similarity object[b]) Trial 2. Baseline condition (rattling set – low similarity object) Trial 3. Predicted condition (squeaking set – low similarity object)
Block 2	Trial 4. Surprised condition (ringing set – dissimilar object) Trial 5. Baseline condition (rattling set – high similarity object) Trial 6. Predicted condition (squeaking set – dissimilar object)
Block 3	Trial 7. Surprised condition (ringing set – low similarity object) Trial 8. Baseline condition (rattling set – dissimilar object) Trial 9. Predicted condition (squeaking set – high similarity object)

[a]Note. The specific object set assigned to each condition was counterbalanced across infants.

[b]Note. The order of presentation of the various test objects (high similarity, low similarity, and dissimilar) was randomized with a high similarity object from a set being presented in one block, a low similarity object presented in another block, and a dissimilar object presented in the remaining block.

(for a total of six times). The manner in which the objects were introduced varied by condition. More specifically, in the gesture condition, the experimenter directed the infant's attention to the object by saying, "Look! This is a (gesture)!" "Look what a (gesture) can do!" (see Appendix for full dialogue). In the novel name condition, the procedure was the same except that objects were introduced with a novel noun. That is, the experimenter introduced a target object by saying, "Look! This is a (wug)!" "Look what a (wug) can do!". In the no label condition, the objects were introduced in a similar fashion, however without any label or gesture (e.g., "Look at this one!" "Look what this one can do!"). After each phrase, the target property was demonstrated (with the exception of the baseline condition in which there was no property to demonstrate). Parents then demonstrated the property with the target object twice, and then passed the object to their infant. Parents only demonstrated the properties with the target objects the first time a target object from each set was introduced. The experimenter, however, continued to demonstrate the properties with the target object each time a target object was introduced. Infants were then allowed to explore the target object for 10 seconds. After this time elapsed, the experimenter retrieved the target object and placed it on the table, still within the infant's view, but out of his or her reach. The experimenter then introduced one of the test objects using either the same novel gesture (e.g., "Look at this (gesture)"), the same novel name (e.g., "Look at this (wug)"), or no label (e.g., "Look at this (one)") as was used with the target objects. Infants were then allowed to explore the test object for 20 seconds. This same procedure was repeated for the other 8 trials.

If an object was dropped off the table or moved out of the infant's reach, the experimenter (or parent) placed the object back in front of the infant within his or her reach. Any time lost during a trial due to these occurrences was not compensated for, as they were seen as intentional acts of disinterest or frustration (see Oakes, Madole, & Cohen, 1991). At the end of the testing session, parents were asked to fill out the MacArthur Communicative Development Inventory: Infants Version (MCDI; Fenson et al., 1991) as a measure of their infant's productive vocabulary.

Coding and Data Reduction

A coder who was blind to the hypotheses of the experiment recorded the frequency of target actions performed on the target and test objects. It was not possible for the coder to see whether actions were demonstrated on the objects or if objects actually made sounds when actions were performed on them, as only the experimenter's back was visible on the videotape, and the coding was performed with no audible sound.

The coder followed a detailed coding scheme, which outlined how to code the target action for each object set. For the rattling set, the target action was defined by a moving of the object with the wrist and/or whole arm in a back or forth or up or down motion. A fluid motion (e.g., back and forth) was counted as only one action, but if there was a pause between the motions they were counted as two actions. Hitting the object on the table did not count as a target action. For the ringing set, the target action was defined by a patting or tapping of the object with the hand. A downward motion making contact with the object was considered one action, but an upward motion bringing the hand back from the object was not considered a second action. Touching the top of the object with the finger or hand to poke it or feel it did not count as an action unless a quick tapping action occurred. If the object was tapped with two hands together, it counted as only one action, unless the tapping occurred at two separate times. For the squeaking set, the target action was defined by a squeezing of the fingers together on the object. A release of the muscles of the fingers squeezing the ball was not considered a second action. If the object was squeezed with two hands together, it was counted as only one action, unless the squeezing occurred at two separate times. Finally, coders recorded the frequency of object transfer actions on the test objects. Object transfer actions were defined as the performance of a target action from one object set (e.g., the patting action from the ringing set) on a test object from another set (e.g., the squeaking set).

To establish inter-rater reliability, 22% of the data ($n = 15$ participants) was coded twice. Intraclass correlations (ICCs) were used to establish the level of agreement between the two coders. ICCs assess both the pattern of agreement and the level of agreement of raters and thus provide a more conservative measure of assessing inter-rater reliability than a traditional Pearson correlation (Sattler, 1992). ICC coefficients for target and test object frequency ratings were significant for the gesture condition, ICC (90) = .987, p < .001, and ICC (90) = .998, p < .001, respectively, for the name condition, ICC (90) = .995, p < .001, and ICC (90) = .994, p < .001, respectively, and for the no label condition, *ICC* (90) = .999, $p < .001$, and *ICC* (90) = .991, $p < .001$, respectively. Thus, the two raters were in almost perfect agreement in their coding across all three conditions.

Data were screened to assess for outliers. Infants with frequency of target action standard scores greater than 3.0 standard deviations above or below the mean in the surprised condition were eliminated from the data analyses ($n = 7$; gesture condition, $n = 1$; name condition, $n = 2$; no label condition, $n = 4$).

Results

Infants' performance of target actions on the test objects was examined in four sets of analyses. First, I examined infants' performance of target actions on test objects in the surprised and baseline conditions in all three groups. The mean frequencies of target actions performed on the different test objects at each level of shape similarity within the surprised and baseline conditions for the gesture, name, and no label conditions are presented in Table 3. Second, I examined the influence of shared gestures and shared names on infants' inductive inferences within the surprised condition. Third, I examined the influence of previous experience using signs on the performance of target actions within the surprised condition. Finally, I examined instances of object transfer within the surprised condition.

Frequency of target action analyses

In the first set of analyses, I examined whether the properties of the objects were indeed nonobvious to the infants. That is, it was necessary to ensure that the appearances of the objects did not in some way suggest their underlying properties. This was achieved through a comparison of the mean frequency of target actions in the surprised condition to the mean frequency of target actions in the baseline condition. This comparison allowed for an examination of infants' performance of target actions on test objects when they knew about the property of the target (surprised condition) versus when they were not shown the property (baseline condition). If infants only performed target actions on test objects when the properties of the target actions were demonstrated for them, then we could be confident that the test objects, in themselves, did not suggest the property through their appearances.

Planned dependent t-tests were used to compare the frequency of target actions at

Table 3

Frequency of Target Actions Performed on Test Objects at Each Level of Shape Similarity within the Surprised and Baseline Conditions for Experiment 1

		Shape Similarity to Target		
		High	Low	Dissimilar
Gesture Condition				
	Surprised	3.87 (3.98)	2.17 (2.96)	0.91 (3.20)
	Baseline	0.04 (0.21)	0.13 (0.63)	0.30 (1.46)
Name Condition				
	Surprised	3.00(3.02)	1.83 (2.33)	0.00 (0.00)
	Baseline	0.00 (0.00)	0.22 (0.74)	0.04 (0.21)
No Label Condition				
	Surprised	3.39 (4.67)	0.91 (1.65)	0.22 (0.85)
	Baseline	0.17 (.58)	0.04 (0.21)	0.00 (0.00)

Note. Standard deviations in parentheses.

each level of shape similarity in the surprised and baseline conditions at an alpha level of .05. In the gesture condition, infants performed significantly more target actions on the high similarity objects in the surprised condition ($M = 3.87$, $SD = 3.98$) than in the baseline condition ($M = 0.04$, $SD = 0.21$), $t(22) = 4.70$, $p < .001$. Similarly, in the name condition, infants performed significantly more target actions on the high similarity objects in the surprised ($M = 3.00$, $SD = 3.02$) versus the baseline condition ($M = 0.00$, $SD = 0.00$), $t(22) = 4.77$, $p < .001$. Finally, in the no label condition, infants again more frequently performed target actions on high similarity objects in the surprised condition (M = 3.39, SD = 4.67) versus the baseline condition (M = 0.17, SD = 0.58). For the low similarity objects, infants differed significantly in their performance of target actions in the surprised condition and in the baseline condition across the gesture condition ($M = 2.17$, $SD = 2.96$; $M = 0.13$, $SD = 0.63$, respectively), $t(22) = 3.23$, $p < .004$, the name condition ($M = 1.83$, $SD = 2.33$; $M = 0.22$, $SD = 0.74$, respectively), $t(22) = 3.09$, $p < .005$, and the no label condition ($M = 0.91$, $SD = 1.65$; $M = 0.04$, $SD = 0.21$, respectively), $t(22) = 2.47$, $p < .022$. For the dissimilar objects, however, infants did not significantly differ in their performance of target actions in the surprised and the baseline conditions in the gesture condition ($M = 0.91$, $SD = 3.20$; $M = 0.30$, $SD = 1.46$, respectively), $t(22) = 0.81$, $p > .05$, the name condition ($M = 0.00$, $SD = 0.00$; $M = 0.04$, $SD = 0.21$, respectively), $t(22) = 1.00$, $p > .05$, or the no label condition ($M = 0.22$, $SD = 0.85$; $M = 0.00$, $SD = 0.00$, respectively), $t(22) = 1.23$, $p > .05$. Overall, these results indicate that the properties of the objects were indeed nonobvious to the infants, as they only performed the target actions after those actions had been demonstrated for them in the surprised condition.

In the next set of analyses, I examined the influence of shape similarity and label group on infants' generalization of nonobvious properties within the surprised condition only, as this was the main condition of interest. Recall that the surprised condition allows for an examination of infants' expectations about shared properties. It was assumed that infants would persist in trying to invoke a particular target action on a test object when they judged the test object to share a similar property as the target object (thus showing their inference that the two objects belonged to the same category). Note that I did not examine the data from the predicted condition in these analyses. Recall that in the predicted condition, both the target and the high and low similarity test objects possessed the same nonobvious property, which could be elicited by a particular target action (the dissimilar object did not possess the property). Any analysis of data from the predicted condition is complicated by the fact that it is difficult to interpret why infants continued to perform target actions on test objects in this condition. That is, it was impossible to distinguish those target actions performed as a result of an expectation about an object's nonobvious property from those performed as a result of the reinforcing nature of the sound property of the test objects themselves (see Baldwin et al., 1993; Welder & Graham, 2001 for a similar argument). Again, this condition was included merely to ensure that infants did not get frustrated or bored if they realized that all the test objects were not functional.

Using a 3 (Group: gesture, name, no label) x 3 (Shape Similarity: high, low, dissimilar) mixed-model analysis of variance (ANOVA), I compared how often infants performed the target action on test objects as a function of shape similarity, and presence of a gesture, name, or no label. Group was a between-subjects factor and shape similarity was a within-subjects factor. As Mauchley's test of sphericity was significant for the effect of shape, W = .86, p < .008, the Greenhouse-Geisser adjustment to degrees of freedom was used. The ANOVA yielded only a significant main effect of shape, F (1.76, 116) = 24.87, MSE = 6.49, p < .001. The main effect of group and the group by shape interaction were not significant.

Paired t-tests with a Bonferroni correction (alpha level of .05/3 = .016) were used to examine the shape main effect. As predicted, infants performed significantly more target actions on the high similarity objects (M= 3.42, SD= 3.91) than on the low similarity objects (M= 1.64, SD= 2.40), t (68) = 4.22, p < .001, and the dissimilar objects (M= 0.38, SD= 1.93), t (68) = 6.15, p < .001. Infants also performed significantly more target actions on the low similarity objects than on the dissimilar objects (t (68) = 3.48, p < .001). The results of these analyses indicate that infants in all three groups expected objects that shared a high degree of shape similarity to share nonobvious properties, consistent with the hypotheses.

In the third set of analyses, I used planned contrasts to examine the effect of providing a novel name or gesture on infants' generalization of nonobvious object properties. Thus, the frequency of target actions performed in the surprised condition on the high similarity objects and on the low similarity objects was compared when infants were provided with shared gestures or shared names or no labels. The alpha level remained at .05, as the comparisons were each separate planned t-tests which did not follow from an omnibus analysis (see Maxwell & Delaney, 1990). Note that one-tailed t-tests were used here as the predictions were directional. More specifically, it was hypothesized that when infants were provided with either the same name or the same gesture for a target and test object, the role of shape should be attenuated (in comparison to infants provided with no labels) such that these infants should be more likely to generalize object properties even when objects share only minimal perceptual similarity.

These comparisons indicated that infants did not differ in their generalizations of target actions to the high similarity objects when provided with shared gestures versus shared names, t (44) = .84, p > .05, shared gestures versus no labels, t (44) = 0.37, p > .05, or shared names versus no labels, t (44) = .34, p > .05. When presented with the low similarity objects, there were no significant differences in infants' performance of target actions when they were provided with shared gestures or shared names, t (44) = .44, p > .05. However, infants did perform significantly more target actions on the low similarity objects when provided with shared gestures versus no labels, t (44) = 1.78, p = .04. Similarly, infants in the novel name group showed a trend to perform target actions more frequently on test objects than infants in the no label group, t (44) = 1.53, p = .065. These results indicate that infants are able to make use of shared gestures to guide their inferences about object properties, and that they show a tendency to use shared names to make generalizations about object properties even when target and test objects are not highly similar in shape.

Finally, I examined the influence of previous experience in using signs on the frequency of target actions within the surprised condition. Recall that infants' experience using signs was determined through parental report. Independent groups t-tests were used to compare the mean frequency of target actions at each level of shape similarity for the gesture, name, and no label conditions. It was particularly important to examine this data in the gesture condition, as previous experience using signs could potentially influence differently whether infants would rely on gestures to make generalizations about object properties. In the gesture condition, those infants having previous experience with signs (n = 11, M = 5.18, SD = 3.66) performed significantly more target actions on the high similarity test objects than infants not having previous experience with signs (n = 11, M = 1.64, SD = 1.96), t (20) = 2.83, p = .01. However, these groups did not differ in performance on the low similarity objects (M= 2.18, SD = 1.72; M = 1.55, SD = 3.36, respectively), t (20) = .56, p > .05, or the dissimilar objects (M = 1.27, SD = 4.22; M = 0.64, SD = 2.11, respectively), t (20) = .45, p > .05. In the name condition, there were no differences in performance of target actions between those having previous experience using signs (n = 7) and those not having previous experience (n = 16) when presented with the high similarity objects (M = 3.14, SD = 3.19; M = 2.94, SD = 3.04, respectively), t (21) = 0.15, p > .05, or the low similarity objects (M = 0.71, SD = 1.11, M = 2.31, SD = 2.58, respectively), t (21) = 1.56, p > .05. Note the comparison of these groups could not be performed with the dissimilar objects as both of these groups had standard deviations of zero. In the no label condition, there were also no differences in performance of target actions between those having previous experience using signs (n = 7) and those not having previous experience (n = 16) with high similarity (M = 4.00, SD = 4.87; M = 3.13, SD = 4.72, respectively), t (21) = 0.41, p > .05, low similarity (M = 1.00, SD = 2.24; M = 0.88, SD = 1.41, respectively), t (21) = 0.16, p > .05, or dissimilar objects (M = 0.00, SD = 0.00; M = 0.31, SD = 1.01, respectively), t (21) = 0.80, p > .05.

Object Transfer Data Analyses

In the final set of analyses, I examined instances of object transfer within the surprised condition. Recall that object transfer was defined as the performance of a target action from one object set (e.g., the patting action from the ringing set) on a test object from another set (e.g., the squeaking set). To examine whether infants were restricting target actions to appropriate test objects or simply trying any type of target action previously seen on other object sets, I compared the number of target actions to the number of transfer actions performed on the high similarity and low similarity test objects in the surprised condition, using t tests. In the gesture condition, infants performed significantly more target actions ($M = 3.87$, $SD = 3.98$) than transfer actions ($M = 0.52$, $SD = 1.20$) on the high similarity objects, $t(22) = 3.48$, $p < .002$. Similarly, infants also performed significantly more target actions ($M = 2.17$, $SD = 2.96$) than transfer actions ($M = 0.48$, $SD = 1.41$) on the low similarity objects, $t(22) = 2.31$, $p < .031$. In the name condition, infants performed significantly more target actions ($M = 3.00$, $SD = 3.02$) than transfer actions ($M = 0.26$, $SD = 0.86$) on the high similarity objects, $t(22) = 3.99$, $p < .001$. Similarly, infants also performed significantly more target actions ($M = 1.83$, $SD = 2.33$) than transfer actions ($M = 0.04$, $SD = 0.21$) on the low similarity objects, $t(22) = 3.60$, $p < .002$. In the no label condition, infants performed significantly more target actions ($M = 3.39$, $SD = 4.67$) than transfer actions ($M = 0.17$, $SD = 0.58$) on the high similarity objects, $t(22) = 3.22$, $p < .004$. In contrast, there was no significant difference between infants' performance of target actions ($M = 0.91$, $SD = 1.65$) and transfer actions ($M = 0.61$, $SD = 1.34$) on the low similarity objects, $t(22) = .64$, $p > .05$. These results indicate that in all three groups, infants were more likely to perform target actions than transfer actions on the high similarity test objects, rather than simply trying any type of action previously seen. Furthermore, these analyses provide further evidence that infants provided with either shared gestures or shared names did view the low similarity object as a member of the same category as the target object, as infants in these groups were more likely to perform target actions than transfer actions on these objects. Finally, these analyses demonstrate that infants in the no label group did not view the low similarity object as a member of the same category as the target object as there was no difference in the type of action (transfer vs. target) performed on the objects.

Discussion

The results of this experiment indicate that 14-month-old infants will generalize knowledge about specific nonobvious object properties gained during just a brief exposure to a novel object to other objects perceived as belonging to the same category. This finding is congruent with the results of previous studies that have examined inductive abilities during infancy (e.g., Baldwin et al., 1993; Graham et al., 2001; under review; Welder and Graham, 2001). Infants generalized object properties significantly more often when the properties were demonstrated for them (in the surprised condition) than when they had no knowledge of the object properties (in the baseline condition), indicating that the object properties were indeed nonobvious. Furthermore, infants did not generalize object properties to the dissimilar objects in the gesture, name, or no label conditions, suggesting that in all of these conditions, infants were not imitating indiscriminately. That is, infants did not just imitate any action that was demonstrated for them, but rather, only generalized the nonobvious properties to objects that they perceived as belonging to the same category as the target object. Since the dissimilar objects did not share any features (shape, color, or texture) with the target objects, there was no reason for infants to judge them as belonging to the same category.

Exactly how infants perceive objects as belonging to the same category seems to depend upon the type of information available. Infants in all three groups used information that is usually highly reliable to determine category membership, namely shape similarity. Thus, whether provided with shared gestures, shared names, or no labels, infants were more likely to generalize an object property of a target object to objects that were highly similar in shape than to objects that were less similar in shape. Thus, the presence of labels did not lead infants to completely overlook shape information.

Infants in the gesture group and the name group also seemed to be able to use the conceptual information provided by the label to determine category membership. Thus, when provided with shared gestures, infants generalized the nonobvious property to both the high and low similarity objects. When provided with shared names, infants also showed a trend to generalize the nonobvious property to both the high and low similarity objects. The fact that the results with the shared names versus no labels only approached significance may merely be the reflection of a power issue that could potentially be resolved with a larger sample size. Note however, that comparisons of the performance of target actions on the low similarity objects in the gesture versus the name condition revealed that there were no differences between these groups. Thus, when provided with either names or gestures, infants treated both as naming the object category and used this information to judge that two objects shared a nonobvious property, even when the objects shared only minimal perceptual similarity, an issue discussed further in the *General Discussion*.

Finally, analyses comparing infants who had previous experience with gestures to those not having previous experience indicated that these infants did not behave differently from each other except in the gesture condition. Infants having previous experience with gestures were more likely to perform actions on high similarity test objects than infants not having previous experience with gestures. These results suggest that having previous experience using or seeing gestures used in a referential manner helps infants to realize that objects labeled with the same gesture belong to the same category, particularly when those objects are highly similar in shape. However, having previous experience with gestures does not influence infants' categorization of objects that are not high in shape similarity, as infants did not differ in their performance of target actions when they had experience versus when they did not.

EXPERIMENT 2

The purpose of Experiment 2 was to examine whether 22-month-old infants will rely on either shared object labels or shared gestures to guide their inferences about nonobvious object properties. The design of Experiment 2 was exactly the same as Experiment 1. Recall that recent research has demonstrated a developmental shift in infants' acceptance of nonlinguistic information (e.g., gestures, sounds) as object labels. That is, younger infants seem to accept this type of information as labeling object categories, while older infants do not (e.g., Namy & Waxman, 1998; 2002; Woodward and Hoyne, 1999). Thus, it was predicted that 22-month-old infants would rely on shared object names, but not shared gestures, to guide their inferences. Therefore, 22-month-olds were expected to perform similarly to the 14-month-olds when provided with the same object names for the target and test objects. However, it was hypothesized that they would rely on perceptual information (i.e., shared shape similarity) to guide their inferences when provided with either the same gesture or no label for the objects. Specifically, it was hypothesized that infants in the surprised condition would perform target actions on test objects that were given the same name when the target and test objects were either high or low in shape similarity. In contrast, because research (i.e., Namy, 2001, Namy & Waxman, 1998; 2002) has indicated that older infants no longer interpret gestures as referring to or naming object categories, it was hypothesized that when infants were either given the same gesture or no labels for the target and test objects they would perform target actions only on test objects that were highly similar in shape to the target object in these groups.

Method

Participants

Data from 60 21.5- to 23-month old infants were included in this study, with 20 infants assigned to each between-subject group (gesture condition, name condition, or no label condition). In the gesture condition, there were 8 males and 12 females with a mean age of 22.40 months (*SD* = .35; range: 21.59 to 22.89 months). In the name condition, there were 10 males and 10 females with a mean age of 22.39 months (SD = .46; range: 21.52 to 22.95 months). In the no label condition, there were 10 males and 10 females with a mean age of 22.23 months (*SD* = .37; range: 21.43 to 22.95 months). An additional twenty infants were tested, but were excluded from the final sample for the following reasons: excessive fussiness (*n* = 11), parental interference (n = 2), experimenter error (n = 2), and statistical outliers (*n* =5; see Data Reduction section). The infants were recruited through advertisements in health clinics as well as in local newspapers. All of the infants were given a t-shirt, a small toy, and a Child Scientist certificate for their participation. None of the infants had participated in Experiment 1. Ethical approval was obtained from the University of Calgary Conjoint Faculties Research Ethics Board. Informed consent was obtained from parents before beginning the testing session, and parents were also informed that they were free to withdraw from the study at any time.

Materials and Equipment

Identical to Experiment 1.

Design

Identical to Experiment 1.

Procedure

Identical to Experiment 1.

At the end of the testing session, parents were asked to fill out the MCDI (Toddlers Version) as a measure of infants' productive vocabularies. Infants' productive vocabulary size ranged from 25 to 517 words (M = 243.67 words, SD = 148.40) in the gesture condition, 42 to 578 words (M = 258.73 words, SD = 167.47) in the name condition, and 5 to 664 words (M = 289 words, SD = 200.85) in the no label condition. There were no differences in infants' productive vocabulary size between the name and gesture conditions, t (28) = 0.26, $p > .05$, the gesture and no label conditions, t (31) = 0.72, $p > .05$, or the name and no label conditions, t (31) = 0.46, $p > .05$.

Parents were also asked on the consent form whether or not they used signs or gestures at home with their children. Of the 20 infants in the gesture condition, parents reported 10 of them to have previous experience using signs. In the name condition, 5 out of 20 infants were reported to have previous experience using signs, whereas in the no label condition 6 of 20 had previous experience.

Coding and Data Reduction

Coders, blind to the experimental hypotheses, coded the frequency of target actions performed on test objects using the same criteria as Experiment 1. Twenty percent of the sessions ($n = 12$ participants) were coded a second time to assess inter-rater reliability. As in Experiment 1, ICC coefficients for target and test object frequency ratings were significant in the gesture condition, ICC (36) = .982, $p < .001$, and ICC (36) = 1.00, $p < .001$, respectively, in the name condition, ICC (36) = .999, p < .001, and ICC (36) = .997, p < .001, respectively, and in the no label condition, ICC (36) = .993, p < .001, and ICC (36) = .997, p < .001, respectively. Thus, the two raters were again in almost perfect agreement in their coding across all three conditions.

As in Experiment 1, infants with frequency of target action standard scores greater than 3.0 standard deviations above or below the mean in the surprised condition were eliminated from the data analyses ($n = 5$; gesture condition, $n = 2$; name condition, $n = 1$; no label condition, $n = 2$).

Results

Infants' performance of target actions on the test objects was examined in five sets of analyses. First, I examined infants' performance of target actions on test objects in the surprised and baseline conditions. The mean frequencies of target actions performed on the different test objects at each level of shape similarity within the surprised and baseline conditions for the gesture, name, and no label conditions are presented in Table 4. Second, I examined the influence of shared gestures and shared names on infants' inductive inferences within the surprised condition. Third, I examined the influence of previous experience using signs on the performance of target actions within the surprised condition. Fourth, I examined instances of object transfer within the surprised condition. Finally, I examined developmental differences in infants' performance of target actions within the surprised condition.

Frequency of Target Action Analyses

In the first set of analyses, I examined whether the properties of the objects were indeed nonobvious to the infants. As in Experiment 1, this was achieved through a comparison of the mean frequency of target actions in the surprised condition to the mean frequency of target actions in the baseline condition. Dependent t-tests were used to compare the frequency of target actions at each level of shape similarity in the surprised and baseline conditions. In the gesture condition, infants performed significantly more target actions on the high similarity objects in the surprised condition ($M = 4.85$, $SD = 4.18$) than in the baseline condition ($M = 0.70$, $SD = 1.63$), $t\ (19) = 4.05$, $p < .001$. Similarly, in the name condition, infants performed significantly more target actions on the high similarity objects in the surprised ($M = 6.70$, $SD = 6.99$) versus the baseline condition ($M = 0.10$, $SD = 0.31$), $t\ (19) = 4.24$, $p < .001$. Finally, in the no label condition, infants again more frequently performed target actions on high similarity objects in the surprised condition (M = 4.05, SD = 3.23) versus the baseline condition (M = 0.25, SD = 1.12). For the low similarity objects, infants did not significantly differ in

Table 4

Frequency of Target Actions Performed on Test Objects at Each Level of Shape Similarity within the Surprised and Baseline Conditions for Experiment 2

		Shape Similarity to Target		
		High	Low	Dissimilar
Gesture Condition				
	Surprised	4.85 (4.18)	0.85 (1.69)	0.00 (0.00)
	Baseline	0.70 (1.63)	0.60 (1.50)	0.15 (0.67)
Name Condition				
	Surprised	6.70 (6.99)	5.00 (5.29)	0.40 (1.00)
	Baseline	0.10 (0.31)	0.05 (0.22)	0.00 (0.00)
No Label Condition				
	Surprised	4.05 (3.23)	1.80 (2.33)	0.00 (0.00)
	Baseline	0.25 (1.12)	0.45 (1.15)	0.00 (0.00)

Note. Standard deviations in parentheses.

their performance of target actions in the surprised condition and in the baseline condition in either the gesture condition ($M = 0.85$, $SD = 1.69$; $M = 0.60$, $SD = 1.50$, respectively), t (19) = 0.47, $p > .05$, or in the no label condition ($M = 1.80$, $SD = 2.33$; $M = 0.45$, $SD = 1.15$, respectively), t (19) = 2.08, $p > .05$. However, in the name condition, infants did perform significantly more target actions on the low similarity objects in the surprised (M = 5.00, SD = 5.29) versus the baseline condition (M = 0.05, SD = 0.22), t (19) = 4.14, p < .001. For the dissimilar objects, infants did not significantly differ in their performance of target actions in the surprised and the baseline conditions in the gesture condition ($M = 0.00$, $SD = 0.00$; $M = 0.15$, $SD = 0.67$, respectively), t (19) = 1.00, $p > .05$, or in the name condition ($M = 0.40$, $SD = 1.00$; $M = 0.00$, $SD = 0.00$, respectively), t (19) = 1.80, $p > .05$. Note that a t-test could not be performed for the dissimilar objects in the no label condition, as the standard deviations were zero in both the surprised and baseline conditions. Overall, these results indicate that the properties of the objects were indeed nonobvious to the infants, since they only performed the target actions after those actions had been demonstrated for them, as in the surprised condition.

In the next set of analyses, I examined the influence of shape similarity and label group on infants' generalization of nonobvious properties within the surprised condition only. Using a 3 (Group: gesture, name, no label) x 3 (Shape Similarity: high, low, dissimilar) mixed-model analysis of variance (ANOVA), I compared how often infants performed the target action on test objects as a function of shape similarity and presence of a gesture, name, or no label. Group was a between-subjects factor and shape similarity was a within-subjects factor. As Mauchley's test of sphericity was significant for the effect of shape, $W = .79$, $p < .002$, the Greenhouse-Geisser adjustment to degrees of freedom was used. The ANOVA yielded a significant main effect of shape, F (1.66, 94) = 39.76, MSE = 9.69, $p < .001$, and a significant main effect of group, F (2,57) = 4.76, MSE = 18.69, $p < .012$. The group by shape interaction was not significant.

Paired t-tests with a Bonferroni correction (alpha level of .05/3 = .016) were used to examine both of the main effects. Examination of the shape main effect revealed that, as predicted, infants performed significantly more target actions on the high similarity objects (M= 5.20, SD= 5.10) than on the low similarity objects (M= 2.55, SD= 3.86), t (59) = 4.29, $p < .001$, and the dissimilar objects (M= 0.13, SD= 0.60), t (59) = 7.88, $p <$ .001. Infants also performed significantly more target actions on the low similarity objects than on the dissimilar objects (t (59) = 5.22, $p < .001$). The results of these analyses indicate that infants expected objects that shared a high degree of shape similarity to share nonobvious properties, consistent with the hypotheses. Furthermore, examination of the group main effect revealed that infants performed significantly more target actions in the name group (M= 4.03, SD =3.77) than in the gesture group (M=1.90, SD=1.46), t(38) = 2.36, $p < .023$, or the no label group (M=1.95, SD=1.55), t(38) = 2.29, $p < .028$. However, there was no difference in the performance of target actions between the gesture and the no label groups, t(38) = .11, $p > .05$. The results of these analyses indicate that infants expected objects that shared the same name to share nonobvious properties, consistent with the hypotheses.

In the third set of analyses, I examined the influence of shared names and shared gestures on infants' generalization of nonobvious object properties within the surprised condition. Thus, the frequency of target actions performed on the high similarity objects and on the low similarity objects when infants were provided with shared gestures for test objects was compared to the frequency of target actions performed when infants were provided with either shared names or no labels, using planned comparisons. The alpha level remained at .05, as the comparisons were each separate planned t-test which did not follow from an omnibus analysis (see Maxwell & Delaney, 1990). Note that one-tailed t-tests were used here as the predictions were directional. More specifically, it was hypothesized that for infants provided with the same name for a target and test object, the role of shape should be attenuated in comparison to infants provided with either the same gesture or no labels. Thus, infants provided with shared names should be more likely to generalize object properties even when objects share only minimal perceptual similarity. However, because older infants do not tend to treat gestures as naming object categories as they do words, infants in the gesture group should behave similarly to infants not provided with any labels. That is, infants in both the gesture and no label groups should rely on the only information available to them, namely shared shape similarity.

These comparisons indicated that infants did not differ in their generalizations of target actions to the high similarity objects when provided with shared gestures versus shared names, $t\ (38) = 1.02$, $p > .05$, or shared gestures versus no labels, $t\ (38) = 0.68$, $p > .05$. When provided with shared names versus no labels, however, infants' differences in their generalizations of target actions approached significance, $t\ (38) = 1.54$, $p < .065$. This suggests that even with objects that are highly similar in shape, shared names help guide infants inferences about nonobvious object properties. When presented with the low similarity objects, infants performed significantly more target actions when they were provided with shared names versus shared gestures, $t\ (38) = 3.34$, $p < .001$, or shared names versus no labels, $t\ (38) = 2.48$, $p < .009$. However, infants did not significantly differ in their performance of target actions on the low similarity objects when provided with shared gestures versus no labels, t (38) = 1.47, $p > .05$. These results indicate that infants are able to make use of shared names, but not shared gestures, to make generalizations about object properties even when target and test objects are not highly similar in shape.

In the fourth set of analyses, I examined the influence of previous experience in using signs on the frequency of target actions within the surprised condition. Independent groups t-tests were used to compare the mean frequency of target actions at each level of shape similarity for the gesture, name, and no label conditions. Results indicated that in the gesture condition, those infants having previous experience with signs did not differ significantly from infants not having previous experience with signs in their performance of target actions on the high similarity test objects (M = 5.60, SD = 5.38; M = 4.10, SD = 2.60, respectively), t (18) = 0.79, $p > .05$, or the low similarity objects (M = 1.00, SD = 1.89; M = 0.70, SD = 1.57, respectively), t (18) = 0.39, p > .05. Note that a t-test could not be performed with the dissimilar test objects as both groups had zero variance. In the name condition, there were no differences between those having previous experience using signs and those not having previous experience, with high similarity objects (M = 6.00, SD = 5.79; M = 6.93, SD = 7.52, respectively), t (18) = 0.25, $p > .05$, low similarity objects (M = 7.60, SD = 6.19, M = 4.13, SD = 4.88, respectively), t (18) = 1.29, $p > .05$, or dissimilar objects (M = 0.00, SD = 0.00; M = 0.53, SD = 1.13, respectively), t (18) = 1.04, $p > .05$. In the no label condition, there were also no differences between those having previous experience using signs and those not having previous experience, with high similarity test objects (M = 3.33, SD = 2.94; M = 4.36, SD

= 3.43, respectively), t (18) = 0.63, p > .05, or low similarity objects (M = 0.50, SD = 1.23; M = 2.36, SD = 2.50, respectively), t (18) = 1.71, p > .05. Note that a t-test could not be performed with the dissimilar test objects as both groups had zero variance. Thus, whether infants had prior experience with signs or not did not affect their performance of target actions on test objects in the gesture, name, and no label conditions.

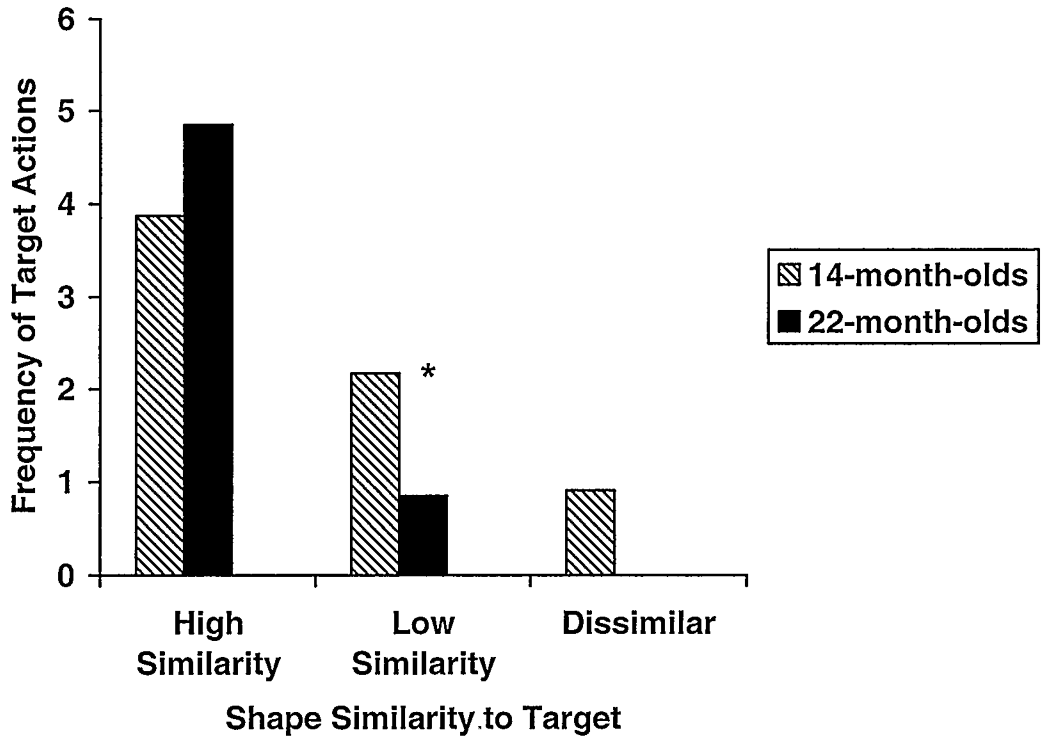
Object Transfer Data Analyses

In the final set of analyses, I examined instances of object transfer within the surprised condition. As in Experiment 1, I compared the number of target actions to the number of transfer actions performed on the high similarity and low similarity test objects, using t tests. In the gesture condition, infants performed significantly more target actions (M = 4.85, SD = 4.18) than transfer actions (M = 0.10, SD = 0.45) on the high similarity objects, $t(19) = 5.02$, $p < .001$. In contrast, there was no significant difference between infants' performance of target actions (M = 0.85, SD = 1.69) than transfer actions (M = 0.95, SD = 1.73) on the low similarity objects, $t(19) = 0.17$, $p > .05$. In the name condition, infants performed significantly more target actions (M = 6.70, SD = 6.99) than transfer actions (M = 0.25, SD = 0.91) on the high similarity objects, $t(19)$ = 4.01, $p < .001$. Similarly, infants also performed significantly more target actions (M = 5.00, SD = 5.29) than transfer actions (M = 1.50, SD = 3.94) on the low similarity objects, $t(19) = 2.32$, $p < .032$. In the no label condition, infants performed significantly more target actions (M = 4.05, SD = 3.25) than transfer actions (M = 0.45, SD = 0.89) on the high similarity objects, $t(19) = 5.08$, $p < .001$. In contrast, there was no significant difference between infants' performance of target actions (M = 1.80, SD = 2.33) and transfer actions (M = 1.25, SD = 4.06) on the low similarity objects, $t(19) = .48$, $p > .05$.

These results indicate that in all three groups, infants were more likely to perform target actions than transfer actions on the high similarity test objects, rather than simply trying any type of action previously seen. Furthermore, these analyses provide further evidence that infants provided with shared names did view the low similarity object as a member of the same category as the target object, as infants in this group were more likely to perform target actions than transfer actions on these objects. These analyses also demonstrate that infants in both the gesture group and the no label group did not view the low similarity object as a member of the same category as the target object as there was no difference in the type of action (transfer vs. target) performed on the objects in either of these groups.

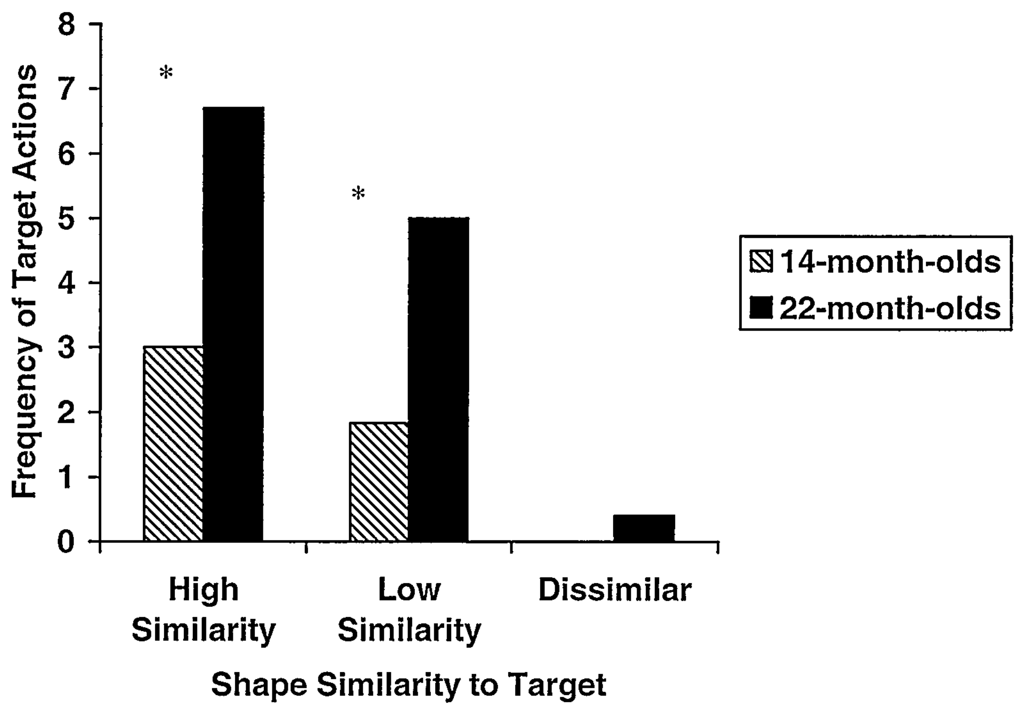
Cross-Experiment Comparisons

Finally, I examined developmental differences in infants' performance of target actions within the surprised condition. Planned comparisons were used to compare the 14-month-olds (Experiment 1) to the 22-month-olds (Experiment 2) on the mean frequency of target actions at each level of shape similarity in the gesture, name, and no label conditions (see Figures 4, 5, and 6). Results indicated that when provided with shared gestures, 14-month-olds tended to make more target actions than 22-month-olds on low similarity objects, $t\ (41) = 1.76$, $p < .08$ (approaching significance). However, with both high similarity and dissimilar objects, there were no differences between the performance of 14-month-old infants and 22-month-old infants, $t\ (41) = 0.79$, $p > .05$, and $t\ (41) = 1.27$, $p > .05$, respectively. This indicates that when provided with shared gestures, younger infants tend to make generalizations about nonobvious object properties even when objects are not highly similar in shape, but older infants do not.



p < .08 (approaching significance)

Figure 4. Cross-Experiment Comparisons: Frequency of Target Actions in the Gesture Condition as a Function of Shape Similarity and Age.



$p < .05$

Figure 5. Cross-Experiment Comparisons: Frequency of Target Actions in the Name Condition as a Function of Shape Similarity and Age.

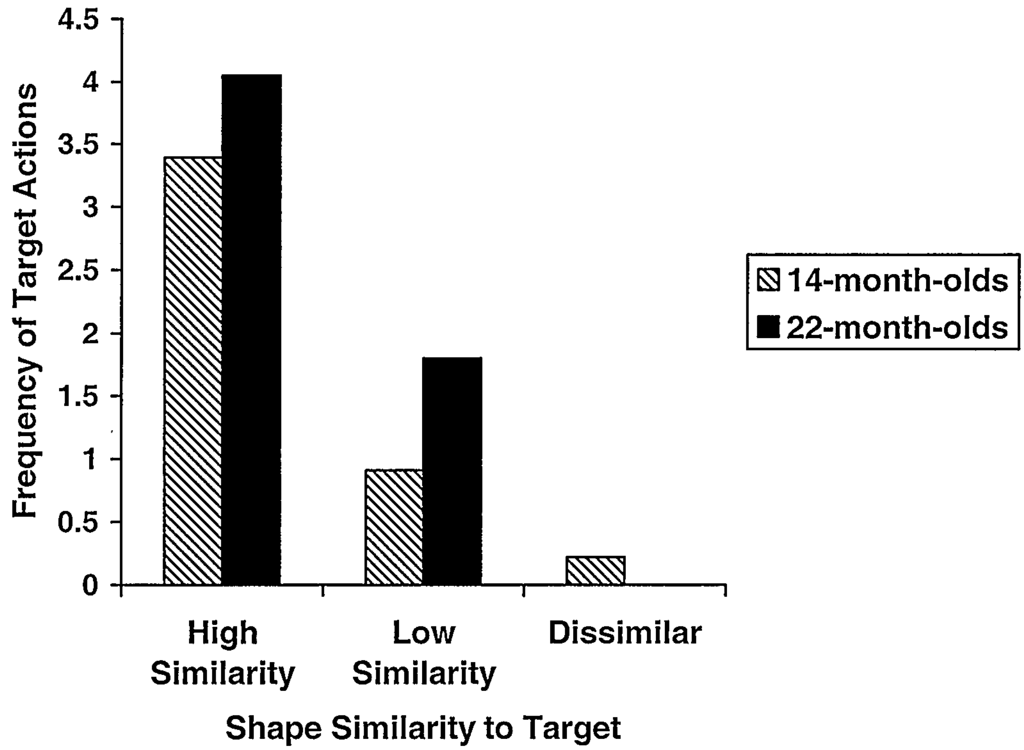


Figure 6. Cross-Experiment Comparisons: Frequency of Target Actions in the No Label Condition as a Function of Shape Similarity and Age.

In the name condition, 22-month-olds performed significantly more target actions than 14-month-olds on both the high similarity objects, t (41) = 2.31, $p < .026$, and the low similarity objects, t (41) = 2.60, $p < .013$, but not on the dissimilar objects, t (41) = 1.93, $p > .05$. These results indicate that for older infants, shared names influence inductive generalizations to a higher degree than for younger infants, for objects that are either high in shape similarity or low in shape similarity. In the no label condition, there were no differences between the age groups on the high similarity objects, t (41) = 0.53, $p > .05$, the low similarity objects, t (41) = 1.41, $p > .05$, or the dissimilar objects, t (41) = 1.14, $p > .05$. Thus, younger and older infants are influenced similarly by shape similarity when making generalizations about nonobvious object properties.

Discussion

Consistent with the results of Experiment 1, 22-month-old infants will generalize knowledge about specific nonobvious object properties to other objects perceived as belonging to the same category. Infants generalized object properties significantly more often when the properties were demonstrated for them (in the surprised condition) than when they had no knowledge of the object properties (in the baseline condition), indicating that the object properties were indeed nonobvious. Furthermore, infants did not generalize object properties to the dissimilar objects in the gesture, name, or no label conditions, suggesting that in all of these conditions, infants were not imitating indiscriminately.

Consistent with the results obtained with 14-month-olds, 22-month-old infants overall, used shared shape information to determine category membership. Thus, it seems that shape information remains an important cue to category membership across the infancy period. However, as in Experiment 1, the type of label information provided about the particular category influenced whether infants perceived other objects as belonging to that same category. Infants in the gesture group and the no label group performed similarly to each other, in that they used shape similarity to determine whether objects belonged to the same category. Thus, infants in these groups generalized an object property of a target object to objects that were highly similar in shape. Infants provided with shared names, however, performed more target actions overall, than infants in the gesture and no label groups. This finding indicates that shared names become very important with age in highlighting object categories. Infants in this group seemed to disregard shape information and used the information provided by the name to determine category membership. Thus, when provided with shared names, infants generalized an object's property to test objects that were both high and low in shape similarity. Note however, that some perceptual similarity was still necessary for infants to make their inferences, as they still did not generalize object properties to the dissimilar objects.

Overall, these findings suggest that by 22 months of age, infants do not tend to treat gestures as naming object categories. Infants in the gesture group seemed to disregard the gestural information they received and behaved similarly to infants not provided with any labels. That is, infants in both the gesture and no label groups seemed to rely on the only information available to them, namely shared shape similarity. These findings will be discussed further in the *General Discussion*.

GENERAL DISCUSSION

The present studies were designed to examine whether linguistic stimuli (i.e., words), as opposed to nonlinguistic stimuli (i.e., gestures), were privileged in guiding 14-

and 22-month-old infants' inferences about nonobvious object properties. In two experiments, I presented infants with novel target objects which either possessed (surprised and predicted conditions) or did not possess (baseline condition) a nonobvious sound property. For those objects that did possess a nonobvious sound property, a target action was demonstrated which could elicit the particular sound. I then presented infants with test objects of varying degrees of shape similarity to the target. These test objects either possessed the same property (predicted condition) as the target or were disabled so that they could not make the sound (surprised and baseline conditions). Target and test objects were either presented with the same novel gesture (e.g., "Look! This is a (*gesture)!*"), the same novel name (e.g., "Look! This is a (*wug*)!"), or no label (e.g., "Look at this *one!").* Infants' performance of target actions on the various test objects was measured to assess their expectations about the generalizability of the nonobvious property. In addition, the performance of 14-month-olds (Experiment 1) was compared to the performance of 22-month-olds (Experiment 2) to examine any developmental change in infants' use of gestures and names in guiding their inferences about object properties.

These studies yielded a number of important insights into the nature of infants' inductive reasoning abilities. First, the results of both experiments provide evidence that shape similarity is an important cue to category membership between 14- and 22-months of age. When objects were not labeled, both 14- and 22-month-old infants were more likely to generalize an object property to objects that were highly similar in shape than to objects that were less similar in shape. Furthermore, cross-experimental comparisons revealed that there were no differences between younger and older infants in their performance of target actions across the levels of shape similarity. Thus, both age groups were influenced by shape similarity when making inferences about object properties. In addition, infants in the no label groups did not generalize the nonobvious properties to low similarity objects (which still shared textural similarity with the target object) or dissimilar test objects. These findings suggest that infants privilege shape information over textural information when relying on perceptual cues to make inferences about object kind.

The finding that infants rely on shape information over textural information is consistent with past research demonstrating the importance of shape similarity over other perceptual cues (such as color and size) in object categorization (e.g., Baldwin, 1989; Graham & Poulin-Dubois, 1999; Landau, Smith, & Jones, 1988; 1992; Smith, Jones, & Landau, 1992). It is perhaps not surprising that infants would privilege shape information over other perceptual cues, as object shape is often highly predictive of category membership, at least at the basic level (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Also, recall Gelman's (2003) argument that an object's underlying nature or kind is often associated with and predictive of its observable properties, such as object shape. Because infants in the present studies used shape information to license their inductive inferences about nonobvious object properties, it seems that infants attend to shape information as another cue to object kind, rather than just as a perceptually salient feature that is common between objects. This finding adds to the on-going debate between those researchers who consider shape information as a cue to object kind and those who consider infants' reliance on shape information as a "dumb attentional mechanism", in which infants are merely focusing their attention on perceptually salient features. More specifically, these findings argue against the idea that infants' reliance on shape information is simply due to a dumb attentional mechanism. That is, infants do not seem to be just making simple perceptually-based associations between object shape and other contextual information, such as repeated linguistic contexts (e.g., "This is a ___"). These findings suggest, conversely, that infants in this case are treating object shape as a conceptual feature. Infants are able to realize that objects with the same shape belong to the same kind, and are then able to use that information to guide their inferences about those objects.

Second, the results of these studies indicate that shared names are influential in 22-month-old infants' inductive inferences. Thus, when target and test objects were labeled with the same novel name, infants relied on the shared name to generalize the nonobvious property, performing target actions on test objects even when they shared minimal perceptual similarity to the target object. The 14-month-olds exhibited the same tendency to rely on shared names to guide their inferences when objects were low in shape similarity, however, their results did not reach significance. The nonsignificant finding with the 14-month-olds in the present study most likely reflects a power issue, as the same procedure with 12-month-olds in Graham et al. (2001, under review) yielded significant findings. That is, 12-month-olds, just beginning to use productive language, used shared names to guide their inferences even when objects were low in shape similarity. Thus, while the results with 14-month-olds were not significant, they did follow the expected pattern in that infants tended to perform more target actions on objects that were low in shape similarity when they were provided with object names versus when they were not provided with any labels.

The findings indicating that shared names are influential in infants' inductive inferences are consistent with past research indicating that shared names assist infants in determining that objects belong to the same category, and thus that they also share nonobvious properties (Graham et al., 2001; under review; Welder & Graham, 2001). Interestingly however, these studies also revealed that younger and older infants behaved somewhat differently when provided with shared names. Fourteen-month-old infants relied on both shape similarity and shared names to make their inferences about object properties. That is, while they performed target actions on objects that were both high and low in shape similarity, they were more likely to perform target actions on high similarity test objects than on other test objects. Twenty-two-month-olds however, disregarded shape information and relied solely on shared names to make their inferences about object properties. That is, they were equally likely to perform target actions on test objects that were high and low in shape similarity. These findings are interesting in that they suggest more of a reliance on shape similarity for inferences at a younger age, which turns into more of a focus on shared names for inferences at an older age. However, these findings again have to be interpreted with caution, as the findings with the 14-month-olds were somewhat unreliable. In fact, Graham et al. (2001; under review) found no shape effect when 12-month-olds were provided with shared names in the same procedure.

Cross-experimental comparisons indicated that 22-month-olds performed significantly more target actions than 14-month-olds on both high and low similarity objects, suggesting that shared names influence older infants' inductive generalizations to a greater extent than younger infants, for objects that are either high in shape similarity or low in shape similarity. The reason for this developmental trend may be due simply to the extraordinary linguistic development that occurs in children at around 18 months of age. Children learn approximately 5 to 6 new words a day between the ages of 18 months and 6 years (Anglin, 1993). Perhaps further experience for older infants in using names to discuss and refer to object categories results in an even greater facilitation of naming in their categorization of objects. That is, it may be that 22-month-olds have fully come to the realization that objects labeled with the same name belong to the same category and share similar underlying properties. In contrast, 14-month-olds, who are just beginning to develop their language skills, may be just beginning to have this same understanding, and thus show less generalization than older infants when objects are either high or low in shape similarity.

Third, the results of these studies also revealed that nonlinguistic information in the form of shared gestures is used differently by younger and older infants when objects share minimal perceptual similarity. That is, when 14-month-olds were provided with shared gestures, they generalized object properties to objects even when they were low in shape similarity. However, 22-month-olds disregarded the gestural information and relied solely on shape information to guide their inferences. Thus, when provided with shared gestures, 22-month-olds only generalized object properties to objects that were high in shape similarity. Cross-experimental comparisons revealed that younger infants tended to perform more actions than older infants on low similarity objects, suggesting that younger infants can make use of gestural information even when objects are low in shape similarity, but that older infants do not. Thus, younger infants assume that two objects labeled with the same symbolic gesture belong to the same category and thus expect them to share similar properties. However, older infants do not treat gestures as category labels, and thus, do not generalize objects properties in the same way as they do when provided with shared names. These findings are consistent with past research demonstrating that younger infants will accept gestures (and other symbolic forms) as naming object categories, but older infants will not (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). The findings from these studies also add incrementally to the findings of Namy and her colleagues (Namy, 2001; Namy & Waxman, 1998). The present studies are perhaps an even stronger test of infants' acceptance of gestures as names for object categories than the Namy et al. studies, which used a forced-categorization task requiring infants to choose between two test objects, one from the same category as the target (e.g., fruit) and one from a totally unrelated category (e.g., furniture). In the present studies, infants do not merely have to choose between two very different objects to show whether they understand that gestures name object categories, but rather, they have to use the information provided by the gesture to decide whether two objects share similar underlying properties. Thus, infants in this situation must not only realize that the gesture can name the object category, but also that this information can be used to guide their inferences about shared properties.

One explanation for the observed developmental shift in infants' use of gestures to guide their inductive inferences is similar to that provided for the developmental pattern found in infants' use of names to guide their inferences. Thus, more experience with the type of symbol used most frequently in their environment (i.e., words) may focus infants to categorize objects on the basis of that information. Thus, early in development infants may accept various symbols to guide their inferences about object kinds, as they do not have as much experience at that time in using a particular symbol to communicate about objects. However, later in their development, as they gain more experience using words to communicate about objects, infants may focus solely on words, as opposed to other symbols (e.g., gestures), as a guide to their categorization of objects. That is, with more linguistic experience, older infants may narrow or orient their biases to accept words as highlighting object categories.

One limitation of these studies is the sample size. Infants in these age ranges are highly variable in terms of their behavior (e.g., attention span, shyness, number of actions they perform when making inferences, etc.), making it all the more difficult to find significant differences in their behavior when the sample size is not large enough. There were several trends in the present studies that may have been significant findings with a somewhat larger sample size.

One direction for future research will be to examine whether young infants will still rely on gestures in guiding their inductive inferences about object properties when the gestures are provided in the absence of a linguistic phrase. Fulkerson and Haaf (2003) put forth the argument that studies finding that infants accept gestures as denoting category membership may only reach these findings because the gestures are delivered within the context of a linguistic phrase that is itself meant to direct attention and denote reference (e.g., "Look at the (gesture)"; "We call this one (gesture)"). As previously mentioned, the results of their study indicated that 9- and 15-month-old infants' categorization was facilitated when provided with labeling phrases, but not when provided with non-labeling sounds. Thus, according to their argument, the finding in the present studies that young infants will use gestures as a cue to category membership may merely stem from the fact that the gesture was introduced within the context of a linguistic phrase. This argument is unlikely however, since it cannot only be the linguistic phrase influencing their inferences, as infants in the no label group behaved very differently but still were introduced to the objects with a similar linguistic phrase (e.g., "Look at this one"). Thus, while it is apparent that it is not merely the presence of a linguistic phrase that drives infants' inductive inferences, future research examining infants' reliance on gestures without the context of a linguistic phrase would clarify this issue even further.

In sum, the results of these studies suggest that infants possess a more generalized language system early in development such that they will perceive both words and gestures as delineating object categories, which then narrows into a more specialized system in which only words are perceived as specifying particular object categories. Future research should be directed at examining whether young infants will still rely on gestures to guide their inductive inferences about object properties when the gestures are provided in the absence of a linguistic phrase. Furthermore, it will also be important to investigate whether they will still rely on names to guide their inferences in the absence of this labeling phrase, and to examine any developmental trends in their use of this information. It is a possibility that young infants require the presence of a linguistic phrase to treat anything (i.e., both words and gestures) as a symbolic referent.

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Appendix

<u>Novel Gesture Condition</u>

Look______! This is a (**gesture**)! Here is a (**gesture**)! Here is a (**gesture**)!
*Look what a (**gesture**) can do! (movement 2x) See what a (**gesture**) can do! (movement 2x) Yes, a (**gesture**) can do this! (movement)*
(Give to parent and say Yes! Here is a (**gesture**)!) (Parent does movement 2X)
(Give to baby and time 10 seconds, then place to side) Okay…Thank you.

Okay _________! Look at this (**gesture**)! Here is a (**gesture**)! Look at this (**gesture**)! Here is a (**gesture**)! (Time 20 seconds)
Okay let's try another one!! (Take both away)

<u>Novel Name Condition</u>

Look______! This is a (**name**)! Here is a (**name**)! Here is a (**name**)!
*Look what a (**name**) can do! (movement 2x) See what a (**name**) can do! (movement 2x) Yes, a (**nam** can do this! (movement)*
(Give to parent and say Yes! Here is a (**name**)!) (Parent does movement 2X)
(Give to baby and time 10 seconds, then place to side) Okay…Thank you.

Okay _________! Look at this (**name**)! Here is a (**name**)! Look at this (**name**)! Here is a (**name**)! (Time 20 seconds)
Okay let's try another one!! (Take both away)

<u>No Label Condition</u>

______! Look at this is (**one**)! Here is (**one**)! Here is a (**one**)!
*Look what this (**one**) can do! (movement 2x) See what this (**one**) can do! (movement 2x) Yes, this (**one**) can do this! (movement)*
(Give to parent and say Yes! Here is (**one**)!) (Parent does movement 2X)
(Give to baby and time 10 seconds, then place to side) Okay…Thank you.

Okay _________! Look at this (**one**)! Here is (**one**)! Look at this (**one**)! Here is (**one**)! (Time 20 seconds)
Okay let's try another one!! (Take both away)

Note: In the baseline condition where no actions are demonstrated on the target objects, the section denoted by * is slightly different. Since no actions are demonstrated, the dialogue for this part is as follows: "Look at this (gesture/name/one)! See this (gesture/name/one)! Yes, this is a (gesture/name/one)!