

## Words and Gestures: The Role of Sentence Context in Infants' Mapping of Novel Symbols to Object Categories

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### 1. Introduction

Infants as young as 12 months of age begin producing words, using them in relatively consistent and systematic ways to refer to objects, actions, and people in the world (Fenson Dale, Resnick, Bates, Thal, & Pethick, 1994; Waxman & Hall, 1993; Waxman & Markow, 1995; Woodward, Markman & Fitzsimmons, 1995). This remarkable early ability has lead researchers to focus on the issue of how infants acquire words. What conditions must be met in order for the infant to successfully map a word to its meaning?

Some researchers have assumed that the processes underlying word acquisition are unique to word learning from the start, guiding early learning (see, e.g., Petitto, 1988, Scidenberg & Petitto, 1987; Mervis & Bertrand, 1993; Behrend, 1990; Grant & Karmiloff-Smith, 1991). Inherent in these accounts is the assumption that word learning is too daunting a problem to solve without the assistance of inherent capacities, dedicated specifically to the acquisition of a linguistic system.

An alternative account is predicated on the assumption that, although word learning requires an appreciation of the symbolic and referential nature of a word, the ability to map a word to its meaning does not depend upon processes unique to linguistic symbols. This view is consistent with the argument that language may derive out of a more general symbolic capacity (Inhelder & Piaget, 1964; Werner & Kaplan, 1963; Bruner, 1975a, 1975b). These theorists have argued more specifically that the capacity to use words originates in an ability to use gestures communicatively. Although the argument that a general symbolic capacity supports word learning has been important throughout the history of cognitive development, and has received observational support, it has yet to be tested experimentally.

Observational support for this position comes from work by Acredolo and Goodwyn (1985, 1988) and Iverson, Capirci, and Caselli (1994). Acredolo and Goodwyn's studies of infants ages 11 to 24 months of age reveal several interesting outcomes. First, over 85% of the infants studied used both words and gestural symbols to communicate. The gestures that infants utilized were often extracted from ritualized routines in which infants and parents regularly engaged, but were used in ways that were markedly similar to the infants' use of words. Infants employ both words and gestures to label and request objects and events. Importantly, infants began to produce their first symbolic gestures at approximately the same point in development that they produced their first words. These findings suggest that infants may use the same set of symbolic processes to acquire their first words and their earliest symbolic gestures.

However, Acredolo and Goodwyn (1985, 1988; Goodwyn & Acredolo, 1993) also report developmental change in infants' use of symbolic gestures. Although infants appear to use words and gestures with equal facility at the onset of symbol development, the use of symbolic gestures generally declines markedly following the onset of combinatorial speech. Iverson et al. (1994) also report that 16-month-olds use both words and symbolic gestures to name objects, but by 20 months, the infants had essentially ceased to use symbolic gestures as object names, relying almost exclusively on verbal names. These observational findings suggest a developmental shift in the processes used in early word-learning. Although younger infants appear to use words and gestures interchangeably to label and request objects, older infants appear to develop a priority for words as object names.

In the two studies presented here, we test experimentally infants' ability to learn words and gestures as names for object categories. We introduce novel words and novel gestures within identical experimental contexts, to provide a strong test of the claim that early word-learning is a product of a general symbolic capacity. Further, we explore the issue of developmental change in infants' symbolic ability. We predict that older infants will be less likely to learn gestures than their younger counterparts.

We test these hypotheses by borrowing a forced-choice categorization paradigm from the word-learning literature. Previous research has shown that infants who are introduced to a novel word as a label for a target category perform better on the categorization task than do children in no word control conditions (Markman & Hutchinson, 1984; Markman & Wachtel, 1988; Waxman & Kosowski, 1990; Waxman & Hall, 1993; Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Woodward, et al., 1994). This robust finding presents us with an opportunity to compare infants' performance on this task when learning words, to their behavior when learning symbolic gestures. If the processes underlying word learning are dedicated uniquely to words (i.e., those symbols that are part of the infants' native linguistic system) then heightened performance on the categorization task should be present for children learning words but not gestures. In contrast, if the processes underlying word learning support symbols more generally, then we should find heightened performance on the categorization task when the target category is labeled with either a word or a gesture, relative to the no label control condition.

### 2. Study 1

In the first study, we test experimentally the hypotheses that: 1) young infants will interpret both novel symbolic gestures and novel words as names for object categories and 2) the tendency to interpret gestures as names for object categories will decline with age and language experience.

We tested infants of two ages, 18 months and 26 months. These age represent two distinct stages in the ontogeny of language and gesture use. At 18 months, most infants are still in the single word stage and still use symbolic gestures to communicate. At 26 months, most infants have begun to combine words into phrases and the use of symbolic gestures has declined.

At each age, infants were randomly assigned to the Word, Gesture, or No-Symbol control condition. In the Word condition, infants heard members of a target category (e.g., an orange and an apple from the target category fruit) labeled with a novel word, those in the Gesture condition saw category members labeled with a novel non-iconic gesture, and those in the No-Symbol condition saw the objects without any label. Infants were then asked to select between an additional category member (e.g., a pear) and an unrelated distractor (e.g., a chair) as a match for one of the target objects.

Based on previous research, we expected that infants at both 18 and 26 months would select category members more frequently in the Word condition than in the No-Symbol condition. Of particular interest was performance in the Gesture condition. We predicted that at 18 months, infants would succeed at learning both words and gestures as object names, but that at 26 months, the likelihood of learning gestures would decline. If so, 26-month-olds in the Gesture condition would perform similarly to those in the No-Symbol rather than the Word condition.

## 2.1 Procedure

The procedure involved two phases: an introduction phase and a test phase.

Introduction Phase: During the introduction phase, the experimenter presented two members of the target category (e.g., an orange and an apple) and drew the infant's attention to each of the objects five times, while the infant played freely with the objects. The manner in which the experimenter referred to the objects varied by condition. In the No-Symbol condition, the experimenter referred to the objects but did not label them, using phrases like "Look at this one!" and "Do you like this one?" In the Word condition, the experimenter referred to the objects using a novel count noun, for example, "We call this one a [word]!" and "Look at the [word]!" In the Gesture condition, the experimenter used the same introductory frames, but presented a gesture in the place of the noun phrase, "We call this one [gesture]!" and "Look at this [gesture]!" All gestures were intended to be arbitrary and unrelated to the objects, were selected to be easily imitated by the infants. See Table 1 for a list of the words and gestures employed.

Test Phase: Immediately following the introduction phase, the experimenter presented a series of six test trials for each target category. Each test trial involved a target object (one of the two object used during the introduction period, e.g., the orange) another member of the target category (e.g., a pear) and an unrelated distractor (e.g., a chair). The experimenter focused the infant's attention on the target object and then asked the infant to select between the two test objects (e.g., pear versus chair).

Instructions varied by condition. In the No-Symbol condition, the experimenter pointed to the target object, saying "Look at this one!" She then extended the two choice objects to the infant, saying, "Can you find another one?" In the Word condition, the experimenter said, "Look at the [word]! Can you find another [word]?" In the Gesture condition, the experimenter said, "Look at this [gesture]! Can you find another [gesture]?" After eliciting a

choice for one test pair, the experimenter immediately presented the remaining five test pairs in random sequence. See Table 2 for a sample stimulus set.

Table 1. List of novel words and symbolic gestures.

Novel Words	Novel Gestures <sup>a</sup>
dax	dropping motion, closed fist opening, palm down
rif	side-to-side motion, hand extended as if to shake hands
blik	up-and-down knocking motion with closed fist

<sup>a</sup> these gestures were patterned after gestures used in sign languages (S. Goldin-Meadow, personal communication)

Table 2. Sample Stimulus Set

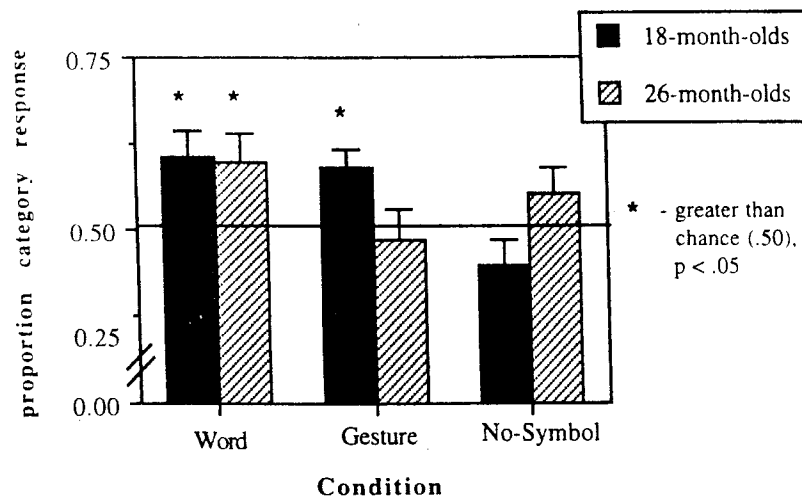
Introduction Phase:	Orange	Red Apple
<u>Test Phase:</u>		
Target Object:	Orange	
Test Objects:		
	<u>Category</u>	<u>Distractor</u>
	1. Red Apple	Pig
	2. Green Apple	Duck
	3. Small Pear	Chair
	4. Large Pear	Bottle
	5. Small Banana	Bed
	6. Large Banana	Hammer

## 2.2. Results and Discussion

The mean proportion of trials on which infants in each condition, at each age, selected category members during the forced-choice task, is depicted in Figure 1. An ANOVA with Condition and Age as between subject factors indicated a main effect of condition ( $p < .001$ ), mediated by an interaction between condition and age ( $p < .05$ ). Post-hoc analyses revealed that infants in

the Word condition selected category members more frequently than did infants in the No-Symbol condition at both 18 and 26 months. However, performance in the Gesture condition differed as a function of age. At 18 months, those in the Gesture condition, like those in the Word condition, were more likely to select category choices than were those in the No-Symbol condition. At 26 months, infants in the Gesture condition, like those in the No-Symbol condition, were less likely to select category choices than those in the Word condition.

**Figure 1. Study 1 Mean Proportion Category Responding in each condition at each age**



This interaction is consistent with the predictions that 1) 18-month-olds would interpret both words and gestures as names for object categories, but that 2) the tendency to interpret gestures as names for object categories would decline with age and language experience. This pattern was also borne out by comparisons to chance responding (.50). As depicted in Figure 1, 18-month-olds selected category members more often than predicted by chance responding in both the Word ( $M = 0.61$ ) and Gesture ( $M = 0.59$ ) conditions, but not the No-Symbol ( $M = 0.45$ ) condition, whereas 26-month-olds responded above chance only in the Word ( $M = 0.60$ ) condition, but not the Gesture ( $M = 0.48$ ) or No-Symbol ( $M = 0.51$ ) conditions.

This outcome supports the argument that infants' symbolic capacities at 18 months encompass both words and gestures, and that they can learn both symbolic forms quite readily. In contrast, 26-month-olds appear more conservative, accepting words but not gestures as object names. This developmental difference in the Gesture condition is consistent with observational evidence on spontaneous gesture use (Acredolo & Goodwyn, 1985, 1988; Iverson et al., 1994) suggesting that the use of symbolic gesture declines with age. However, this finding is striking because younger infants

succeed on an experimental task at which their older counterparts fail. This developmental trend implies that infants' word learning processes may be changing over time. As infants acquire greater verbal lexicons and develop a sensitivity to the distinctive features of the linguistic system (e.g., syntax, pragmatics), they begin to distinguish words from symbol use more generally. As a result, they begin to focus more exclusively on words as names for object categories.

Does this finding imply that 26-month-olds are incapable of learning to use gestures as symbols? In two follow-up studies, we explored in greater detail 26-month-olds' failure to map gestures to object categories (Namy & Waxman, in press). We found that 26-month-olds can learn gestures as object names, but they succeeded in doing so only after explicit training during which the infants practice producing the gestures with feedback. This suggests that older infants require a different, more explicit path of learning when acquiring gestural as opposed to verbal labels.

We turn now to the issue of 18-month-olds' success at learning gestures in this study. Although this result is consistent with the notion that language emerges out of a more general symbolic capacity (Inhelder & Piaget, 1964; Werner & Kaplan, 1963; Bruner, 1975a, 1975b), there is also an alternative explanation. Perhaps infants in the Gesture condition were not tapping into a general symbolic capacity, but rather, used the sentence context to infer that the gestures were being used to name object. Recall that the novel gestures were always embedded within a familiar spoken sentence frame such as "Look at this [*symbol*]!" Because the gesture occurred in the precise place in the sentence frame where an object label typically occurs, infants may have deduced the meaning of the gesture from the language context. That is, infants' knowledge of language and their familiarity with particular sentence frames, rather than a general symbolic ability may have mediated infants' success in the Gesture condition.

This alternative has important implications for our understanding of the processes underlying early word learning (Namy & Waxman, 1997; Roberts, 1997). Therefore, in Study 2, we test the hypothesis that embedding a gesture in a spoken sentence frame facilitated 18-month-olds' success at learning gestures.

### 3. Study 2

This study is designed to compare 18-month-olds' interpretations of novel words and symbolic gestures as names for object categories when they are a) embedded in familiar ostensive naming phrases (the Phrasal condition) or b) presented alone, stripped of any sentence context (the Alone condition).

#### 3.1. Procedure

The procedure was similar to that in the first study. As in Study 1, there was an introduction phase and a test phase. During the introduction phase, the experimenter presented two members of the target category and labeled each five times with a novel symbol (word or gesture). This introduction phase was

followed by a test phase during which infants participated in the forced-choice categorization task described in Study 1.

In Study 2, half of the infants were randomly assigned to the Phrasal condition, in which they were introduced to novel symbols embedded within familiar naming phrases, for example, "Look at this [symbol]!" and "We call this one [symbol]". During the test phase, as in Study 1, the experimenter presented the child with a target object (e.g., an orange) saying, "Look at this [symbol]!" and then presented the two test objects (e.g., a pear and a chair) saying, "Can you find another [symbol]?" This condition is a replication of the effect of symbols in the first study.

The remaining infants were assigned to the Alone condition. In this condition the infants were introduced to the novel symbols in the absence of a sentence frame, for example, "Look here! [symbol]!" and "What's this? [symbol]!" During the test phase, the experimenter presented the target object, saying, "Look! [symbol]!" and then presented the two test objects saying, "What else can you find? [symbol]!"

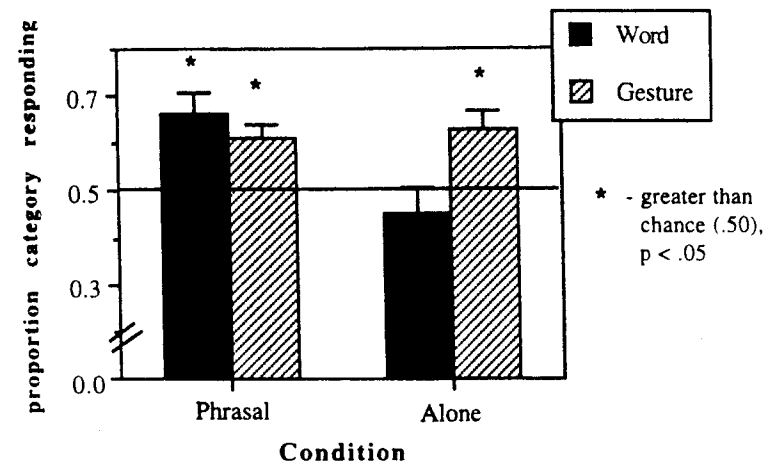
We predicted that, as in Study 1, infants would succeed at learning both words and gestures in the Phrasal condition. Of interest is infants' performance in the Alone condition. If infants depend upon the naming phrases to interpret novel gestures, then infants should fail to learn gestures in the Alone condition. However, if infants do not depend upon the naming phrases to interpret novel gestures, they should succeed at learning the gestures in both the Phrasal and Alone conditions. This would lend support to the view that infants' early word learning is a product of a general symbolic capacity.

### 3.2. Results and Discussion

The mean proportion of trials on which infants in each condition selected category members during the forced-choice task, is depicted in Figure 2. An ANOVA with Condition (Phrasal versus Alone) and Symbol Type (Word versus Gesture) as between subject factors indicated a main effect of condition ( $p < .05$ ), mediated by an interaction between condition and symbol type ( $p < .05$ ). Post-hoc analyses revealed that infants learning words were more likely to select category members in the Phrasal condition than in the Alone condition. However, infants learning gestures were equally successful in both the Phrasal and the Alone conditions.

Furthermore, comparisons to chance responding (.50) revealed that 18-month-olds learning words selected category members more often than predicted by chance responding in the Phrasal ( $M = 0.66$ ) but not the Alone ( $M = 0.45$ ) condition, whereas those learning gestures responded above chance in both the Phrasal ( $M = 0.61$ ) and Alone ( $M = 0.63$ ) conditions.

Figure 2. Study 2 Mean proportion category responding to each symbol in each condition



These results replicate the finding that 18-month-olds learn both words and gestures when they are presented in familiar naming phrases. In addition, we have discovered that infants succeed at learning novel gestures both when they are presented in phrases and when they are presented alone. But these data also reveal an unexpected effect; infants learning novel words fail to interpret them as object names if they are presented alone.

These results have several interesting implications for our understanding of symbol development and word learning. First, they indicate that infants' success at mapping gestures to object categories at 18 months is not simply a product of the naming phrases. Rather, infants succeed at mapping gestures to objects when presented alone as well as in phrases. This outcome supports the argument for a general symbolic ability underlying the early acquisition of words. Second, although 18-month-olds readily learn both words and gestures as names for object categories, these data reveal differences in the circumstances under which infants learn these two symbolic forms. Although 18-month-olds learn gestures both in and out of naming phrases, they succeed at learning words as object names only when they are embedded in naming phrases. This suggests that infants have more conservative expectations about the circumstances under which words name objects, but permit greater latitude of contexts when learning gestures.

Infants' relatively conservative expectations about words as names are likely a product of their history of experience. In the infant's experience, verbal object names typically occur in naming phrases. Thus, the infant learns to associate object names with particular phrases (Roberts, 1997). In contrast, when infants encounter words presented alone, they tend to be commands (e.g., "Stop!") or exclamations (e.g., "Wow!"). Thus, experience leads infants to expect that

words presented alone do not name objects. In the present task, when infants are presented with novel words in isolation, they are reluctant to interpret these words as object labels because experience has led them to expect that words presented alone are not object names. Indeed, Namy and Waxman (1997) have demonstrated that infants' expectations about sentence contexts are based on experience, and that infants' use of sentence contexts as a cue to naming can be altered within an experimental setting. We find that infants who are exposed to several familiar object words presented alone (e.g., "Car!") subsequently interpret novel words presented alone as object names, while infants hearing familiar one-word exclamations (e.g., "Whee!") fail to map novel words to object categories. Thus, infants adapt their expectations about the meaning of words presented alone after a period of exposure to object names presented alone.

As with words, infants' performance in the *Gesture* condition is also consistent with the infants' experience. Although gestures typically accompany speech, they are not consistently embedded in particular sentence contexts. Thus, the infant does not learn to associate particular contexts with gestural labels.

The finding that infants rely on sentence context more when learning words than when learning gestures demonstrates how an initially general symbolic ability may develop into a more specific set of expectations about principles unique to language. Although 18-month-olds display no priority for words over gestures as object names, they have become sensitive to sentential cues to meaning, distinguishing between words presented in naming phrases and words presented in isolation. This rudimentary sensitivity to sentence context highlights how an initial, general symbolic ability may support a later sensitivity to the unique syntactic features of language. Appreciation of regularities in sentence structure may enable infants to acquire some of the more subtle syntactic distinctions that mark words as referring to particular types of meaning (e.g., nouns map on to objects, adjectives map on to properties, and verbs map on to actions).

The findings of this study fit well with those in Study 1. In the first study we found that infants learned both words and gestures at 18 months, but began to focus more exclusively on words later in development. In this study, we document the beginning stages of this divergence between words and gestures, during which infants begin to differentiate, based on experience, the circumstances under which words and gestures tend to name objects. Infants have begun to appreciate that word meaning is governed by a more intricate set of rules that do not apply to symbols more generally, taking their first strides towards a differentiated syntactic system.

#### 4. Conclusions

The primary goal of this paper has been to provide experimental evidence regarding an initial, general symbolic capacity that develops into the linguistic system employed by older language users. The two studies presented here provide strong support for this argument. First, Study 1 provides experimental

evidence that 18-month-olds readily learn both words and symbolic gestures as names for object categories, when presented under the same, experimentally controlled circumstances. Second, this study revealed a developmental change in the relative status of words and gestures within the symbolic system. Although 18-month-olds learned words and gestures with equal facility, 26-month-olds learned words more readily than they learned gestures. This suggests that infants develop a priority for words over other symbols as names for objects, later in development.

Third, we have explored an alternative explanation for 18-month-olds' success at learning symbolic gestures. In Study 2, we examined the possibility that 18-month-olds' success in the *Gesture* condition was a product of the sentential context, that the infants inferred from the naming phrases that the gesture was being used as an object name. We found that infants learned gestures quite readily when they were removed from the sentence context and presented in isolation. Thus, infants do not depend upon the sentence context in order to map novel gestures to object categories, so their success at learning gestures is more likely the consequence of a symbolic capacity that extends to words and gestures alike.

Finally, we have documented how experience with language may enable children to 1) distinguish words from other symbolic forms and 2) develop some more stringent expectations about the circumstances under which words name objects that do not apply to symbols more generally. That is, we have demonstrated how experience with a language system may enable infants to derive a rudimentary syntactic sensitivity from an initial, general symbolic ability. In Study 2, we find that 18-month-olds' have developed some expectations about which sentence contexts are likely to signal a naming event. The infants readily mapped words presented in naming phrases to object categories but were reluctant to map words presented alone to object categories. Thus, these studies reveal some important aspects of the mechanisms underlying early word-learning and how they change with development. The evidence presented is consistent with the notion that an early, general symbolic ability may develop in to the infant's native linguistic system over time, as she accrues experience with her native language.

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