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Words and Gestures: Infants' Interpretations of Different Forms of Symbolic Reference

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In 3 experiments, we examine the relation between language acquisition and other symbolic abilities in the early stages of language acquisition. We introduce 18- and 26-month-olds to object categories (e.g., fruit, vehicles) using a novel word or a novel symbolic gesture to name the objects. We compare the influence of these two symbolic forms on infants' object categorization. Children at both ages interpreted novel words as names for object categories. However, infants' interpretations of gestures changed over development. At 18 months, infants spontaneously interpreted gestures, like words, as names for object categories; at 26 months, infants spontaneously interpreted words but not gestures as names. The older infants succeeded in interpreting novel gestures as names only when given additional practice with the gestural medium. This clear developmental pattern supports the prediction that an initial general ability to learn symbols (both words and gestures) develops into a more focused tendency to use words as the predominant symbolic form.

INTRODUCTION

Early in development, infants begin to use symbols to refer to objects, actions, and events in the world. This symbolic capacity is a fundamental aspect of human cognitive function and manifests itself in many aspects of everyday life such as the ability to read and interpret maps, to understand traffic signals, to interpret wedding rings as an index of marital status, and to use written and spoken language. Words, like traffic signals and wedding rings, can serve as symbols. However, unlike many symbolic forms, words are embedded in a complex, generative linguistic system. Language incorporates a fundamental ability to symbolize but also elaborates upon it in ways that other symbolic forms do not.

Thus, although linguistic and symbolic abilities clearly overlap, language learning requires more complex abilities than learning a simple symbol-to-referent mapping (such as learning that a green light means *go*). However, this distinction between language acquisition and symbol development is less clear at the point when infants first start to produce words. Infants' initial strides in word acquisition involve predominantly learning to make word-to-referent mappings, for example, learning what objects in the world the words "Mommy" and "doggy" indicate. Thus, early word acquisition focuses on the symbolic nature of words. This developmental fact leads to the primary focus of this article, how the general ability to learn symbols relates to word acquisition, early in language development.

The goal of these studies is to examine the extent to which infants distinguish between words and other types of symbols and how the distinction between word-learning and other symbolic behaviors might change with development. Much of the literature on early word-learning has made the assumption that the processes underlying word acquisition are unique to words from the onset of acquisition (see, e.g., Behrend, 1990; Grant & Karmiloff-Smith, 1991; Mervis & Bertrand, 1993; Petitto, 1988; Seidenberg & Petitto, 1987). A review of recent literature leads us to consider the possibility that early word acquisition is a function of a general symbolic ability, implying that infants would learn words and other symbolic forms with equal facility at the onset of word acquisition. However, we propose that later in development, word-learning diverges from symbol development more generally, as infants begin to employ those features of language that distinguish it from general symbol use.

Work by Acredolo and Goodwyn (1985, 1988) has assessed directly the relation between word-learning and other symbolic communication at the onset of productive language, using case study, cross sectional and longitudinal methods with participants ranging from 11 to 24 months of age. These studies report that over 85% of infants used symbolic gestures, as well as words, to label, to request, and to express an intention to retrieve or search for objects. As predicted by Piaget and other traditional theorists (Bruner, 1975a, 1975b; Inhelder & Piaget, 1964; Werner & Kaplan, 1963), these gestures were typically extracted from ritualized routines, but they were also extended to novel instances and in novel contexts. For example, after seeing her mother repeatedly per-

form a spider-crawling movement with her fingers while singing "Itsy-bitsy Spider," one infant spontaneously began to perform a similar spider-crawling gesture not only during the song but also in reference to spiders that she encountered, both live and in pictures.

Infants appeared to use symbolic gestures in ways that were virtually identical to the way that they employed words. Words and gestures were used in the same manner (i.e., to label or request) and for the same types of referents for which they were acquiring words (e.g., animals, food, clothing). Moreover, the infants demonstrated very little overlap between their word and gesture lexicons. That is, if an infant had acquired a gesture for a particular referent, she tended not to have a word for the referent, and vice versa. Importantly, infants tended to produce their first symbolic gestures at around *the same time* or possibly even earlier than they produced their first words (Goodwyn & Acredolo, 1993). This evidence supports the hypothesis that infants can learn words and gestures with equal facility at the onset of language acquisition.

However, Acredolo and Goodwyn (1985, 1988; Goodwyn & Acredolo, 1993) also report developmental change in infants' use of words and gestures as symbols. Although there are individual differences in the longevity of infants' gestural vocabularies, the use of symbolic gestures generally declined markedly following the onset of combinatorial speech. Consistent with this finding, Iverson, Capirci, and Caselli (1994) also found that at 16 months, infants used both words and symbolic gestures to name objects, but that by 20 months, the infants had essentially ceased to use symbolic gestures as names for object categories. This finding implies that, over time, word learning diverges from symbol use more generally and that words take on a privileged status in the infant's communicative repertoire.

The discovery that infants have a shared ability to acquire words and gestures suggests that common symbolic processes may underlie word acquisition and the acquisition of other symbolic forms such as gestures. This hypothesis is consistent with the developmental fact that infants acquiring gestural language such as American Sign Language learn them with a facility equal to that of those acquiring spoken languages (Petitto, 1988). But more importantly, even hearing infants who are learning *only* a spoken language also appear to use gestures symbolically at the onset of word acquisition. However, the finding that words supplant gestures later in development is consistent with the fact that spoken language becomes the hearing infant's predominant and most productive form of symbolic communication.

In the current studies, we test experimentally the hypothesis that an early, general ability to learn symbols gives rise to a more unique focus on words, later in development. We compare infants' ability to learn novel words or novel gestures as names for object categories. We focus on infants at two distinct points in development, 18-month-olds who are still in the single-word utterance stage and still use symbolic gestures to communicate, and 26-month-olds who have begun to combine words and for whom the use of symbolic gestures has declined. In our first experiment, we test the hypothesis that (1) early in acquisition, at the single-word stage, infants will readily interpret both words and gestures as names for object categories, but that (2) later in development, following the onset of combinatorial speech, these symbolic forms will diverge. More specifically, we predict that younger infants will be equally likely to learn words and gestures as names for object categories, but older infants will be more likely to interpret words than gestures as names for object categories. In two subsequent studies, we examine the conditions under which older infants can successfully interpret gestures as names for object categories.

To provide a strong test of our hypothesis, we introduce words and gestures under similar circumstances. The words and gestures we employ were all novel and were presented ostensively as names for objects. It is important to point out that the types of gestures we employ are quite distinct in two ways from those spontaneously learned by infants (Acredolo & Goodwyn, 1985, 1988; Goodwyn & Acredolo, 1993; Iverson et al., 1994). First, the gestures we present are non-iconic, and second, they are introduced unaccompanied by a spoken label. In this respect, the gestures we use more closely resemble the type of input infants receive when introduced to novel words.

Our procedure involves a forced-choice categorization task similar to those used in many studies of early word learning. Previous research has shown that infants who are introduced to novel words in such tasks focus more attention on object categories than do children in no-word control conditions (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Markman & Hutchinson, 1984; Markman & Wachtel, 1988; Waxman & Hall, 1993; Waxman & Kosowski, 1990; Waxman & Markow, 1995; Woodward, Markman, & Fitzsimmons, 1994). This robust finding presents us with the opportunity to compare the role of gestures and words. In the three studies reported here, we in-

troduce the infants to members of two different superordinate level categories (fruit and vehicle). We assign infants to either a novel *Word*, novel *Gesture*, or *No Symbol* control condition. Infants in the Word condition hear members of the target category (e.g., an orange and an apple) labeled with a novel word, those in the Gesture condition see the category members labeled with a novel, non-iconic gesture, and those in the No Symbol condition are shown the objects without any label. The infants are then asked to choose 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 (e.g., the orange). We select superordinate categories because in past studies of word learning, the influence of novel words is most apparent at the superordinate level (Waxman & Hall, 1993; Waxman & Markow, 1995).

If infants recruit both words and symbolic gestures as names for object categories, then infants in both the Word and Gesture conditions should select category members more frequently than infants in the No Symbol condition. However, if infants more readily interpret words than gestures as names for object categories, we should find that those in the Word condition select category members more frequently than those in either the Gesture or No Symbol condition.

EXPERIMENT 1

This study examines whether infants can learn novel symbolic gestures as well as novel words as names for object categories and whether the influence of a novel symbol changes over development. We compare performance on a forced-choice triad task in a Gesture, a Word, and a No Symbol condition in infants at 18 and 26 months of age. Infants at these ages are successful at the forced-choice task (Bauer & Mandler, 1989; Waxman & Hall, 1993; Waxman & Kosowski, 1990). But more importantly, we selected these ages because they tend to represent two distinct stages of language and gesture usage. 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. Based on previous research (Golinkoff et al., 1992; Markman & Hutchinson, 1984; Markman & Wachtel, 1988; Waxman & Hall, 1993; Waxman & Kosowski, 1990; Waxman & Markow, 1995; Woodward et al., 1994), we predict that at both ages, infants in the Word condition will select category members more frequently than those in the No Symbol condition. Of particular interest for this study was the performance in the Gesture condition. We expect that at 18 months, infants will map both words and gestures to object categories, but that at 26 months, performance in the Gesture condition will resemble the No Symbol rather than the Word condition.

Method

Participants

Forty-eight 18-month-olds (*M* age = 17.9, *range* = 16.8–18.6) and 48 26-month-olds (*M* age = 25.9, *range* = 25.1–26.7) from the greater Chicago area participated in this study. Participants were from predominantly white, middle-class families who were recruited via direct mailings and advertisements in parenting magazines.

In the 18-month-old sample, we included only infants who were not yet combining words (according to parental report). We also developed a stringent inclusion criterion for this and subsequent studies, accepting participants who made a clear choice on at least 10 of the 12 trials (see below). An additional 15 18-month-olds were excluded from the analysis due to experimenter error (1), failure to complete the task (11), or failure to make enough clear choices (3). Among those excluded from the analysis, seven were in the Word condition, six were in the Gesture condition, and two were in the No Symbol condition.

In the 26-month-old sample, we included only infants who had begun to combine words (according to parental report). Three additional 26-month-olds were excluded from the analysis due to failure to complete the task. One of the infants excluded was in the Gesture condition, and two were in the No Symbol condition.

Stimuli

Stimuli were 26 plastic toy replicas of objects, ranging from 4.5 cm to 11.5 cm in height. These stimuli were arranged to form two sets of 13 objects each. Each set consisted of seven members of a superordinate level target category (fruit, vehicle) and six unrelated distractor items. One of the seven category members served as a target object, and the other six were each paired with a distractor to serve as test pairs. In selecting these stimuli, we made an effort to choose members of the target category that varied in their perceptual similarity to the target object (e.g.,

Table 1 Experiments 1, 2, and 3: Complete List of Stimuli

Target Category	Category	Distractor
Experiment 1:		
Fruit:		
Training objects:	Orange	. . .
	Apple (red)	. . .
Target object:	Orange	. . .
Test objects:		
Mapping	Apple (red)	Pig
Near	Apple (green)	Duck
Intermediate	Pear (small)	Chair
	Pear (large)	Bottle
Far	Banana (small)	Bed
	Banana (large)	Hammer
Vehicle:		
Training objects:	Van	. . .
	Car	. . .
Target object:	Van	. . .
Test objects:		
Mapping	Car	Key
Near	Pickup Truck	Dog
Intermediate	Airplane	Whale
	Helicopter	Cup
Far	Boat (red)	Boot
	Boat (green)	Couch
Experiments 2 and 3:		
Fruit:		
Training objects:	Orange	. . .
	Apple (small)	. . .
Target object:	Orange	. . .
Test objects:		
Mapping	Apple (small)	Pig
Near	Apple (large)	Bottle
Intermediate	Strawberry (small)	Chair
	Strawberry (large)	Duck
Far	Banana (small)	Spoon
	Banana (large)	Bed
Vehicle:		
Training objects:	Van	. . .
	Car	. . .
Target object:	Van	. . .
Test objects:		
Mapping	Car	Key
Near	Pickup Truck	Dog
Intermediate	Airplane	Whale
	Helicopter	Cup
Far	Boat (red)	Ball
	Boat (green)	Couch

the orange). As is depicted in Table 1, two of the six category choice objects were designated as "Near" in perceptual similarity to the target object (e.g., the apples), two were "Intermediate" (e.g., the pears), and two were "Far" (e.g., the bananas). This design enabled us to examine infants' patterns of extension in greater detail.

Procedure

The infants were tested individually in a laboratory playroom. They were seated directly across a table from the experimenter, with caregivers seated next to the child. Caregivers were asked to avoid interacting with the child and were specifically instructed not to name any of the objects. All sessions were videotaped for subsequent coding.

Infants in each age group were randomly assigned to one of three conditions. There was an initial warm up phase, followed by the experiment proper. The experiment proper was composed of an introduction phase and a test phase for each of two superordinate level object categories (fruit and vehicles).

Warm-up period. The purpose of the warm-up period was to familiarize the infants briefly with the type of symbolic input they would receive during the experiment proper. The infant was permitted to play freely with an unfamiliar toy animal, which was not included in the experiment proper. The experimenter drew the infant's attention to the object twice. The manner in which she referred to the object varied by condition. For infants in the No Symbol condition, the experimenter pointed to the unfamiliar object saying, "Look at that one! See that?" She then held out her hand, palm up, and asked the infant, "Can you show me?" For infants in the Word condition, the experimenter pointed to the unfamiliar object and labeled it using a novel word, saying, for example, "We call this a [*word*]! See the [*word*]?" She then held out her hand and asked the child, "Can you show me the [*word*]?" For infants in the Gesture condition, the experimenter pointed to the object and labeled it with a gesture, using similar syntactic frames as in the Word condition but substituting a gesture for the noun phrase, "We call this [*gesture*]! See this [*gesture*]?" She then held out her hand, asking, "Can you show me [*gesture*]?" All gestures were intended to be arbitrary and unrelated to the objects and were selected to be easily imitated by the infants. See Table 2 for a list of the words and gestures employed. The warm-up object was removed at the end of this period.

Introduction phase. The purpose of this phase was to introduce the infants to the target category and to provide a naturalistic, interactive play session in which the novel symbol was paired referentially with members of the object category (in the Word and Gesture conditions). The experimenter presented two members of the target category, the target object and one Near choice object (e.g., an orange and an apple for the category fruit). She drew the infant's attention to each of the two objects five times while the infant

Table 2 Experiments 1, 2, and 3: List of Novel Words and Symbolic Gestures

Novel Words	Novel Gestures[a]
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
ziv[b]	Repeated simultaneous extension of index and middle finger from a closed fist[b]

[a] These were patterned after gestures used in sign languages (S. Goldin-Meadow, personal communication).
[b] Used only in Experiment 3.

played freely with the objects. The manner in which the experimenter referred to the target objects during play 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*]!"

Test phase. Immediately following the introduction, the test phase was administered. For each target category (fruit and vehicles) there were six test trials, each of which involved a target object (one of the two objects used during the introduction phase, e.g., the orange), another member of the target category (e.g., a pear), and an unrelated distractor (e.g., a chair). To begin each trial, the infant was permitted to play freely with the three objects for 15 s. The experimenter then removed the three objects from the infant's reach. She focused the infant's attention on the target object and asked the infant to select between the two test objects (e.g., pear versus chair). The 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 child, 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*]?"

For each target category, there were two types of test trials, mapping trials and extension trials. On the mapping trial, the category choice was one of the two objects that had been previously labeled during the introduction phase (e.g., the apple). This enabled us to determine whether the infants had made the pairing between the symbol presented during the introduction phase and its referent.

The mapping trial was followed by five extension trials in which the category choices were novel instances of the target category. These trials permitted us to examine infants' willingness to extend a symbol beyond the instances upon which it was taught. To derive a clear picture of infants' extension patterns, we selected category choices that varied in their perceptual similarity to the target. One of the five extension trials from each category was a Near trial, two were Intermediate trials, and two were Far trials (See Table 1 for an illustration of the task structure.)

The order in which extension trials were presented and the left-right placement of the two choice objects in each trial were randomly determined for each child. Order of presentation of the two categories (fruit and vehicle) was counterbalanced within each age and condition.

Coding

Infants' choices on each trial were recorded. Three different types of responses were possible. These included (1) selecting the category member, (2) selecting the distractor, or (3) making no clear choice. Any infant who failed to make a clear choice on more than two out of 12 trials was excluded.

A primary coder analyzed the videotapes of all 96 infants. A second coder analyzed a randomly selected 25% of the infants in each condition at each age. Intercoder agreement on individual trials, calculated using the kappa statistic, was extremely high, $k = .9575$, $p < .001$.

Results

The mean proportion of trials on which infants in each condition selected category members during the forced-choice task, collapsed across the two target categories, is reported in Table 3.

We subjected the data to a four-way analysis of variance (ANOVA) with condition (3) and age (2) as between-subject factors and target category (2: fruit versus vehicle) and trial type (2: mapping versus extension) as within-subject factors. A main effect of condition, $F(2, 90) = 10.66$, $p < .001$, indicated that infants in the Word condition were more likely to select category members than those in either the Gesture or No Symbol conditions, Tukey's HSD, ps <

Table 3 Experiment 1: Mean Proportion Category Responding (and Standard Deviation) at Each Age in Each Condition

Condition	Mapping	Near	Intermediate	Far	Total Extension	Overall Mean
18-month-olds:						
Word	.69	.66	.64	.55	.60	.61
	(.31)	(.36)	(.22)	(.32)	(.17)	(.15)
Gesture	.63	.56	.66	.53	.59	.59
	(.29)	(.36)	(.24)	(.18)	(.10)	(.10)
No symbol	.47	.53	.44	.39	.43	.45
	(.39)	(.29)	(.23)	(.26)	(.19)	(.16)
26-month-olds:						
Word	.88	.63	.61	.45	.55	.60
	(.22)	(.39)	(.29)	(.28)	(.19)	(.17)
Gesture	.34	.56	.52	.47	.51	.48
	(.35)	(.31)	(.27)	(.20)	(.17)	(.18)
No symbol	.47	.50	.56	.50	.52	.51
	(.34)	(.37)	(.27)	(.24)	(.16)	(.15)

.05. Performance in the latter two conditions did not differ reliably from each other.

This main effect of condition was mediated by an age × condition interaction, $F(2, 90) = 3.86$, $p < .05$, reflecting developmental change in the Gesture condition. At both 18 and 26 months, infants in the Word condition selected category members more frequently than did infants in the No Symbol condition, Tukey's HSD, both $ps < .05$. This replicates the previous finding that novel words facilitate object categorization behaviors at these ages (Golinkoff et al., 1992; Markman & Hutchinson, 1984; Markman & Wachtel, 1988; Waxman & Hall, 1993; Waxman & Kosowski, 1990; Waxman & Markow, 1995; Woodward et al., 1994). However, as predicted, performance in the Gesture condition differed as a function of age. Eighteen-month-olds in the Gesture condition, like those in the Word condition, were significantly more likely to select category choices than were those in the No Symbol condition, Tukey's HSD, $p < .05$. At 26 months, infants in the Gesture condition, like those in the No Symbol condition, were significantly less likely to select category choices than those in the Word condition, Tukey's HSD, $p < .05$. This interaction is consistent with the prediction that (1) 18-month-olds would spontaneously 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.

The ANOVA revealed no main effect of trial type. There was a condition × trial type interaction, $F(2, 90) = 4.92$, $p < .01$. This interaction was mediated by a three-way interaction among condition, age, and trial type, $F(2, 90) = 3.61$, $p < .05$. Post hoc analysis indicates that 26-month-olds in the Word condition were more likely to select the category members on mapping trials than on extension trials, but that those in the Gesture and No Symbol conditions were equally likely to select category members on mapping and extension trials, Tukey's HSD, $p < .05$. There was no effect of trial type on 18-month-old infants' performance in any condition.

There was also a main effect of target category, $F(1, 90) = 11.08$, $p < .005$, mediated by a target category × age interaction, $F(1, 90) = 6.342$, $p < .05$. Post hoc analysis indicates that 18-month-olds performed better on the fruit than on the vehicle category, but that 26-month-olds showed no effect of target category, Tukey's HSD, $p < .05$. There was no interaction with condition. There was also a target category × trial type interaction, $F(1, 90) = 7.60$, indicating that, on mapping trials, infants selected category members more frequently on the fruit ($M = 0.69$) than on the vehicle category ($M = .47$); on extension trials, infants selected category members equally often on the fruit trials ($M = 0.55$) and vehicle trials ($M = 0.52$).

We next examined the infants' patterns of extension in more detail by testing whether performance differed as a function of the perceptual similarity between the target and test objects. An age (2) × condition (3) × extension (3: Near versus Intermediate versus Far) yielded an overall linear trend in extension, $F(1, 90) = 6.73$, $p < .05$. Infants were most likely to select category members when they were perceptually more similar to the target. There were no interactions with age or condition.

We also compared performance at each age in each condition to chance responding (.50), collapsing across trial type and target category. Eighteen-

Table 4 Experiment 1: Distribution of Individual Patterns of Behavior at Each Age in Each Condition (n = 16 in Each Condition for Each Age Group)

Proportion Category Choices	18-Month-Olds			26-Month-Olds		
	Word	Gesture	No Symbol	Word	Gesture	No Symbol
Upper third (.67–1.0)	7	6	3	7	2	3
Middle third (.34–.66)	9	9	7	8	11	10
Lower third (.0–.33)	0	1	6	1	3	3

month-olds selected the category members at a rate that exceeded chance in both the Word, $t(15) = 2.77$, $p < .01$, and Gesture, $t(15) = 3.59$, $p < .005$, conditions. Performance in the No Symbol condition did not differ reliably from chance. At 26 months, infants in the Word condition selected the category members more frequently than predicted by chance, $t(15) = 2.40$, $p < .05$, but those in the Gesture and No Symbol conditions did not differ reliably from chance. These results are quite consistent with the patterns of results indicated in the ANOVA.

Finally, to examine how representative these group data were of individuals' performance, we also examined the distribution of individual patterns of responding. Table 4 presents the number of infants who selected category members on .67 proportion of trials or more (upper third), .34–.66 proportion of trials (middle third), and 0–.33 proportion of trials (lower third). Because we were primarily interested in comparing performance in the Word and Gesture conditions, we used Fisher's exact test to compare the relative proportion of infants who were in the upper third (as opposed to the lower two-thirds) in the Word and Gesture condition, at each age.

At 18 months, the number of infants in the upper third did not differ between the two conditions, $p = .264$. These findings suggest that for the 18-month-olds, the similar rate of category responding in the Word and Gesture conditions is the result of reliable trends across infants in each condition, rather than the product of one or two "outliers." However for the 26-month-olds, the number of infants in the upper third did differ as a function of condition, $p = .049$. This suggests that the higher mean rates of category responding in the Word than the Gesture condition is the result of consistent differences in responding across individual infants within the two conditions.

Discussion

The results of this study supported our predictions that (1) 18-month-olds would apply novel symbols to object categories in both the Word and Gesture conditions, but (2) 26-month-olds would do so in the Word but not the Gesture or No Symbol conditions. At 18 months, infants acquiring a spoken language show no apparent differences in their categorization performance when learning a novel word or a novel gesture. After only 10 exposures to either a spoken or gestural symbol, infants mapped the word or gesture onto the labeled objects and spontaneously extended this symbol to other members of the superordinate category which had not been previously labeled. This suggests that infants' initial symbolic capacities are flexible enough to accommodate both words and gestures and that they learn both symbolic forms quite readily. In contrast, 26-month-olds mapped only the novel word to object categories. In the Gesture condition, infants performed at chance and did not differ from infants in the No Symbol condition.

This developmental difference in the Gesture condition is quite striking, in part because older infants fail to reveal a symbolic capacity to learn gestures whereas younger infants succeed. Why were the older infants less likely than the younger infants to interpret the gestures symbolically? We know that the categorization task itself was not too difficult, because infants in the Word condition performed well above chance, as has been reported in previous word-learning studies (e.g., Waxman & Hall, 1993; Waxman & Kosowski, 1990). How, then, can we characterize this shift in behavior? We suspect that the ability to interpret gestures is still within the 26-month-old's symbolic repertoire but that this ability is more difficult to recruit at 26 months than at 18 months.

There are several possible reasons for this apparent difficulty. First, the older infants' failure to interpret gestures as names for object categories may be related to the fact that the gestures were embedded within a spoken sentence. Twenty-six-month-olds may have acquired an expectation that *words* but not gestures are presented within a sentence context, whereas the 18-month-olds have not yet developed this expectation. Thus, 26-month-olds may find our

introduction of gestures within a spoken sentence odd, whereas 18-month-olds are unaffected by the fact that the gestures are embedded within spoken sentences. A second possible account for the developmental change observed in the Gesture condition is that infants may become more conservative, with age and experience, about what types of symbols that they will take to refer to objects. In the next two experiments, we explore the conditions under which 26-month-old infants can recapture the ability to interpret a gesture symbolically.

EXPERIMENT 2

In this experiment, we attempted to teach 2-year-olds that a gesture, like a word, may be used to name an object. To accomplish this, we introduced symbols (either words or gestures) within the context of a familiar naming routine. Typical middle-class North American families engage frequently in naming routines (known as the Dubbing Ceremony or the Original Word Game) in which parents produce or elicit names for objects in a ritual-like manner, asking for example, "What's this?" (Brown, 1956; Putnam, 1975).

To approximate these naming routines, we used a puppet who identified objects using either a word (Word condition), a gesture (Gesture condition) or a simple point (No Symbol condition). The puppet provided names for various objects in response to the experimenter's query, "What's this?" There are two advantages to this "dialogue" between experimenter and puppet. First, it permits us to remove the symbols from a sentence frame, because the puppet can respond to the query with an isolated symbol. Second, because gestures are embedded in a familiar naming routine, this method may encourage the infants to overcome their conservative stance with respect to gestures. If this is the case, then the infants should interpret gestures (like words) as names for object categories.

Method

Participants

Participants were 36 27-month-old infants (M = 26.8, *range* = 24.5–29.8) recruited from the same population used in Experiment 1. Because only 5% of the 26-month-olds contacted for Experiment 1 were not yet combining words, we did not include this specific selection criterion in Experiments 2 and 3. Seven additional infants were excluded from the analysis because of equipment failure (2), failure to complete the task (4), or failure to make enough clear choices (1). Among those excluded from the analysis, two were in the Word condition, four were in the Gesture condition, and one was in the No Symbol condition.

Stimuli

The stimuli were 26 toy replicas of objects (see Table 1). The objects were arranged into two sets. As in Experiment 1, each set was composed of seven members of the target category (fruit or vehicle) and six unrelated distractors. We also used a hand-puppet (Charlie the Cricket), which was a stuffed animal that had been sewn to the back of a glove. The puppet was ideally suited to perform any gesture that can be performed by a human hand.

Procedure

Infants were tested individually in the laboratory playroom. They were seated across a table from the experimenter with caregivers seated next to the child. Caregivers were asked to avoid interacting with the child and were specifically instructed not to name any of the objects. All sessions were videotaped for subsequent coding.

Infants were randomly assigned to either a Word, a Gesture, or a No Symbol condition. As in Experiment 1, there was a warm-up period followed by the experiment proper, including an introduction and a test phase. Each infant completed the task twice, once with the fruit category and once with the vehicle category. Order of presentation of the two categories was counterbalanced within each condition.

Warm-up period. The purpose of the warm-up period was to familiarize the infants with the puppet and introduce them to the type of symbolic input they would receive. The experimenter introduced the infants to Charlie the Cricket and then permitted the infant and puppet to interact briefly. In the Word condition, she explained that "Charlie speaks a different language, so he has special names for things." In the Gesture condition she explained that "Charlie can't talk, but he uses his hands to speak." In the No Symbol condition, infants were not given any specific information about Charlie.

Introduction phase. The experimenter then presented two members of the target category (e.g., an apple and an orange for the fruit category). She drew the infant's attention to each of the two objects five times while the infant played freely with the objects. See Table 5 for an example. In the Word condition, she asked Charlie to label the objects by asking, "Charlie, what's this?" She then focused the infant's

Table 5 Experiments 2 and 3: Example Instructions to Charlie during the Teaching Phase

Condition	Experimenter	Charlie	Experimenter
Word	"Charlie, what's this? Listen!"	"A dax!"	"Wow! A dax!"
Gesture	"Charlie, what's this? Watch!"	[Gesture]	"Wow! [Gesture]"
No symbol	"Charlie, look at this!"	[Points]	"Charlie likes that!"

attention on Charlie's response by saying, "Listen!" Each time Charlie said the word, the experimenter immediately repeated it. The infant was encouraged to imitate the word. Charlie applied the same word to both objects in each target category. In the Gesture condition, she asked Charlie to label the objects by asking, "Charlie, what's this?" She then focused the infant's attention on Charlie's response by saying, "Watch!" Each time Charlie produced the gesture, the experimenter immediately repeated it with her free hand. The infant was encouraged to imitate the gesture. Charlie applied the same gesture to both objects in each target category. In both the Word and Gesture conditions, the symbol was used five times in reference to each object, for a total of 10 labeling instances. In the No Symbol condition, the experimenter focused the infant's attention on each object but offered no label, e.g., "Look at this one!" and "Charlie likes this one!"

Test phase. The experimenter presented the infant with each of the test pairs. The pairs of objects (including a category member and a distractor) are described in Table 1. Unlike in the previous experiment, the target object was not included. This was because pilot testing suggested that the infants were confused by the presence of a target object when the puppet was present. The task appeared to be more straightforward for the infants when they were simply asked to select an object for the puppet.

To begin each trial, the infant was permitted to play with the pair of objects for 15 s. Then, the experimenter held up the two objects and elicited a choice. In the Word condition, the experimenter said, "Let's help Charlie! Listen! A [*word*]! Can you find it?" The experimenter then placed the two objects within the infant's reach and extended her hand between the two choice objects, palm up. In the Gesture condition, the experimenter said, "Let's help Charlie! Watch! [*gesture*]. Can you find it?" In the No Symbol condition, the infant was told "Let's help Charlie! Can you find one for him?"

As in the previous experiment, there were six test trials for each category. Infants always received one mapping trial followed by five extension trials. The category choices for the five extension trials again varied in perceptual similarity to the target. The trials for each category included one Near trial, two Intermediate trials, and two Far trials. The order in which extension trials were presented and the left-right placement of the two choice objects in each trial were randomly determined for each child.

Coding

Coding was identical to that in the previous experiment. A primary coder reviewed all the sessions, and a secondary coder analyzed a randomly selected 33% of infants in each condition. Intercoder agreement on individual trials, calculated using the kappa statistic, was extremely high, $k = .8684$, $p < .001$.

Results

The mean proportion of trials on which infants in each condition selected the category member during the forced-choice task, collapsed across the two target categories, is reported in Table 6.

We subjected these data to a three-way ANOVA with condition (3) as a between-subjects factor and target category (2: fruit versus vehicle) and trial type (2: mapping versus extension) as within-subject factors. This analysis yielded a main effect of condition, $F(2, 33) = 10.56$, $p < .001$. As in Experiment 1, 27-month-olds in the Word condition selected category members more frequently than infants in the Gesture and No Symbol conditions, Tukey's HSD, all ps $< .05$. Performance in the Gesture and No Symbol conditions did not differ reliably. There were no effects of target category or trial type. Importantly, infants in the Gesture condition did not even succeed on the mapping trials, suggesting that they did not even make the pairing between the gesture and labeled object.

We next examined the infants' patterns of extension in more detail by testing whether performance differed as a function of the perceptual similarity between the target and test object. A condition (3) $\times$ extension (3: Near versus Intermediate versus Far) ANOVA yielded no effect of extension. Performance on the categorization task did not differ as a function

Table 6 Experiment 2: Mean Proportion of Category Responding (and Standard Deviation) in Each Condition

Condition	Mapping	Near	Intermediate	Far	Total Extension	Overall Mean
Word	.71	.79	.69	.63	.68	.68
	(.26)	(.33)	(.33)	(.23)	(.21)	(.19)
Gesture	.33	.42	.40	.35	.39	.38
	(.33)	(.36)	(.25)	(.31)	(.18)	(.16)
No symbol	.42	.46	.56	.46	.50	.48
	(.36)	(.40)	(.26)	(.26)	(.15)	(.16)

of the perceptual similarity of the category choice to the target.

We also compared performance in each condition to chance performance (.50) collapsing across trial type. We found that infants in the Word condition selected category members more frequently than would be predicted by chance, $t(11) = 3.36$, $p < .01$. Infants in the Gesture condition selected category members less frequently than predicted by chance, $t(11) = -2.66$, $p < .05$. This outcome for gestures was unexpected, and the cause is unclear. Infants in the No Symbol condition did not differ from chance responding.

Finally, we examined how representative these group data were of individual patterns of performance in each condition. As in Experiment 1, we examined the number of infants who performed in the upper third of possible scores, in the middle third, and in the lower third, reported in Table 7. We compared the relative proportion of infants in the Word and Gesture condition, who were in the upper third (as opposed to the lower two third) of the range of possible scores, using a Fisher's exact test. We found that there were significantly more infants in the upper third in the Word condition than in the Gesture condition, $p < .001$. Thus, individual patterns of behavior appear consistent with the analysis of group performance, suggesting that these 27-month-old infants in the Gesture condition, as in the previous study, consistently failed to interpret gestures symbolically but were consistently successful in interpreting words symbolically.

Table 7 Experiment 2: Distribution of Individual Patterns of Behavior at Each Age in Each Condition (n = 12 per Condition)

Proportion Category Choices	Condition		
	Word	Gesture	No Symbol
Upper third (.67–1.0)	9	0	2
Middle third (.34–.66)	2	7	7
Lower third (.0–.33)	1	5	3

Discussion

These results were somewhat surprising; even when a novel gesture was embedded within a familiar naming routine, 27-month-olds did not interpret the gesture as a name for the object category. These data are consistent with those of the first study, replicating the finding that infants at this age interpret words as names more readily than gestures.

We interpret this finding as further evidence that older infants are conservative in their interpretations of symbolic gestures, even when the gestures are removed from a sentence frame and presented in a familiar naming routine. In the third experiment, we seek to overcome this conservative stance by offering the infants some practice *using* gestures (rather than passively observing them used by Charlie).

EXPERIMENT 3

In this study, as in Experiment 2, we introduced the infants to Charlie the Cricket and explained that he had special names for things. In addition, we introduced an initial training period, during which we provided novel symbols for several different familiar objects. The experimenter produced each symbol repeatedly and gave the infants opportunities to produce and interpret the symbols. She also reinforced their responses, cheering for their correct responses and correcting their incorrect responses. Following this training period, the experimenter administered the forced-choice categorization task used in Experiment 2. If this additional experience producing the gestures in conjunction with the familiar naming routine is sufficient to motivate the infants to interpret novel gestures as names for object categories, then performance in both the Word and Gesture condi-

tions should be elevated, relative to the No Symbol control condition.

Method

Participants

Participants were 36 27-month-old infants (M = 27.6 months, *range* = 25.9–30.5 months). Fourteen additional infants were excluded due to equipment failure (1), failure to complete the task (10), failure to make enough clear choices (1), or a side preference (2). A side preference was defined as selecting objects from the same side of the table on at least 11 of the 12 trials. Among those excluded from the analysis, three were in the Word condition, five were in the Gesture condition, and six were in the No Symbol condition.

Stimuli

The stimuli were 30 toy replicas of objects, including all the objects used in Experiment 2 (see Table 1) and four additional familiar objects (a fish, a cookie, an elephant, and a flower) that were used during the training period. Objects in the training set were unrelated to each other and to the target categories.

Procedure

The procedure was identical to Experiment 2, except that a training period was interjected between the warm-up phase and introduction phase, as noted below.

Training. Following the warm-up phase, we administered a training phase. The purpose of this phase was to give the infants experience with novel symbols referring to familiar objects. The experimenter presented two familiar objects—a cookie and a fish—one at a time and asked the infant to label each object. If the infant did not respond, the experimenter named the object, using its familiar basic-level label (e.g., "fish"). Next, the experimenter explained that they would learn Charlie's name for the object. As in Experiment 2, in both the Word and Gesture conditions, the experimenter asked Charlie, "What's this?" and then focused the infant's attention on Charlie's response by saying, "Listen!" (in the Word condition) or "Watch!" (in the Gesture condition). Charlie produced the symbol a total of four times for each of the two objects. Each time Charlie produced the symbol, the experimenter immediately repeated it. The infants were encouraged to imitate the symbol (e.g., "Did you hear that? Can you say it?" or "Can you do that? Show me!"). In the No Symbol condition, the experimenter focused the infant's attention on the object four times but offered no label (e.g., "Look at this one!" and "Charlie likes this one!").

After four repetitions of the symbol for one of the familiar training objects, the experimenter repeated this process with the second training object. Two of the novel words or gestures listed in Table 2 were used during training; the remaining two were used during the introduction and test phases. Assignment of symbols was random for each participant. Order of presentation of the two objects was counterbalanced within each condition. After providing the symbol for each training object individually, the experimenter presented the two objects simultaneously and had Charlie repeat the symbol for each. In the No Symbol condition, the experimenter focused the infant's attention on each object in turn but did not label them.

To provide the infants with an opportunity to use the symbols in reference to the objects, we elicited production and comprehension of the symbols. The experimenter elicited production by pointing to each object in turn and asking, for example, "Do you remember what Charlie called this?" She elicited comprehension by asking the infant to help Charlie find the toy he asked for. For example, "Let's help Charlie! Watch/Listen!" After Charlie produced the symbol, the experimenter would ask, "Which one is it? Can you find it?" If the infant answered correctly, the experimenter clapped and cheered. If the infant was incorrect, the experimenter provided the correct response. In the No Symbol condition, the infants were simply encouraged to show each of the objects to Charlie (e.g., "Can you show this one to Charlie?" or "Can you find one for Charlie?") and received clapping and cheering in response to their behavior.

Introduction and test phases. The training phase was immediately followed by the introduction and test phases, as in Experiment 2.

Coding

Coding was identical to that in the previous experiments. A primary coder reviewed all the sessions, and a secondary coder analyzed a randomly selected 33% of infants in each condition. Intercoder agreement on individual trials, calculated using the kappa statistic, was extremely high, $k = .914$, $p < .001$.

Results

The mean proportion of trials on which infants in each condition selected the category member during

Table 8 Experiment 3: Mean Proportion of Category Responding (and Standard Deviation) in Each Condition

Condition	Mapping	Near	Intermediate	Far	Total Extension	Overall Mean
Word	.67	.79	.69	.60	.68	.67
	(.39)	(.26)	(.24)	(.29)	(.14)	(.17)
Gesture	.58	.67	.65	.52	.60	.60
	(.29)	(.39)	(.25)	(.13)	(.15)	(.13)
No symbol	.38	.50	.42	.44	.44	.43
	(.43)	(.30)	(.31)	(.31)	(.12)	(.13)

the forced-choice task, collapsed across the two target categories, is reported in Table 8.

We subjected these data to a three-way ANOVA with condition as a between-subjects factor and target category and trial type as within-subject factors. This analysis yielded a main effect of condition, $F(2, 33) = 4.81$, $p < .05$. Infants in both the Word and Gesture conditions selected category members more frequently than infants in the No Symbol condition, Tukey's HSD, both $ps < .05$. Performance in the Word and Gesture conditions did not differ reliably, suggesting that this procedure was successful in eliciting the interpretation of gestures as symbols. The ANOVA revealed no effects of target category or trial type.

We next examined the infants' patterns of extension in more detail by testing whether performance differed as a function of the perceptual similarity between the target and test object. A condition (3) $\times$ extension (3: Near versus Intermediate versus Far) ANOVA yielded a marginal linear trend, $F(1, 33) = 3.87$, $p < .06$. Thus, infants tended to select category members more frequently when they were more perceptually similar to the target. There was no interaction with condition.

We also compared performance in each condition at each age to chance performance (.50), collapsed across trial type. Infants in both the Word, $t(11) = 3.65$, and Gesture, $t(11) = 2.65$, $ps < .05$, conditions selected category members more frequently than would be predicted by chance. Infants in the No Symbol condition performed marginally below chance, $t(11) = -1.82$, $p < .10$.

Finally, as in Experiments 1 and 2, we examined individual patterns of performance in each condition (see Table 9). Using a Fisher's exact test, we compared the relative proportion of infants who were in the upper third of the distribution in the Word and Gesture conditions. We found that the number of infants in the upper third did not differ between the two conditions, $p = .155$. Thus, individual patterns appear consistent with the analysis of group performance which suggests that infants in the Word and Gesture conditions were equally likely to interpret the symbol as referring to the object category.

Discussion

These findings demonstrate that 27-month-olds are quite capable of learning to interpret gestures (like words) as names for object categories. Following a modest amount of practice using gestures as symbols, infants in both the Word and Gesture conditions selected category members more frequently than did infants in the No Symbol condition, and at rates that exceeded chance. Thus, 27-month-old infants can successfully recruit a gesture as a symbol, but they require practice to do so.

GENERAL DISCUSSION

The results of these three experiments provide support for the hypotheses (1) that in the initial stages of productive symbol use, infants have an ability to map both words and gestures to object categories and (2) that over time, infants acquiring a spoken language develop an asymmetry between words and gestures, with words supplanting gestures. We document an important developmental difference in infants' interpretations of novel symbolic gestures. Whereas the 18-month-olds spontaneously interpret

Table 9 Experiment 3: Distribution of Individual Patterns of Behavior at Each Age in Each Condition (n = 12 per Condition)

Proportion Category Choices	Condition		
	Word	Gesture	No Symbol
Upper third (.67–1.0)	9	6	1
Middle third (.34–.66)	2	5	8
Lower third (.0–.33)	1	1	3

arbitrary gestures as names for object categories, 26-month-olds require additional incentive to do so. This developmental pattern supports the view that infants' initial, general symbolic abilities become canalized over time.

These findings advance our existing knowledge about infants' early word acquisition in several ways. First, we have documented that 18-month-old infants succeed in learning an arbitrary gesture as a name for an object category under conditions similar to the typical word-learning experience, after only 10 exposures to the gesture paired with the object category. This finding supports the argument that infants may not have a clear priority for words over other symbols during the early stages of language development. This would suggest that the abilities guiding the onset of word acquisition are not unique to word-learning.

Second, these data reveal a developing appreciation of words as symbols. Although 18-month-olds show equal potential for learning multiple forms of symbolic reference, by 26 months, they map novel words more readily than novel gestures to objects and object categories. This suggests that an initially general symbolic capacity becomes more entrained with time and exposure, leading to a canalization of infants' symbol use. We suspect that this canalization is the result of infants' greater experience using words than gestures as a symbolic medium. However, as we have demonstrated (Experiment 3), the capacity to use gestures as symbols can be successfully recruited by older infants when sufficient incentive to do so is provided. Thus, these studies enable us to more clearly articulate the nature of the abilities utilized by infants at various stages of the word-learning endeavor and to illustrate how these abilities change with time and experience.

These results raise several intriguing questions for future research. One question concerns the precise characterization of the symbol's influence. We must explore whether infants appreciate the referential and representational nature of words and symbolic gestures at the onset of symbol use. To answer this question, we must develop methods to assess whether infants learning novel symbols understand that a symbol *stands for* or names its referents. We must also examine the generalizability of the phenomena observed in these studies. Both words and gestures are part of the infant's natural communicative repertoire. The current experiments do not examine whether infants' early symbolic ability extends beyond words and gestures (e.g., to color chips, pictograms, or melodic sequences).

It is also unclear how the ability to map a symbol to an object or object category relates to the broader range of accomplishments inherent in natural language acquisition and symbol development. For example, can infants map symbolic gestures to object properties or actions, as well as object categories? It will also be important to examine how infants' early symbolic behaviors relate to the acquisition of subsequent abstract symbol systems such as map reading and mathematical notation. The answers to these questions will advance further our understanding of the mechanisms underlying the fundamental symbolic and linguistic abilities developing during infancy and early childhood.

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