JOURNAL OF COGNITION AND DEVELOPMENT, *5*(1), 37–57

The Changing Role of Iconicity in Non-Verbal Symbol Learning: A U-Shaped Trajectory in the Acquisition of Arbitrary Gestures

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This article reports 2 experiments examining the changing role of iconicity in symbol learning and its implications regarding the mechanisms supporting symbol-to-referent mapping. Experiment 1 compared 18- and 26-month-olds' mapping of iconic gestures (e.g., hopping gesture for a rabbit) vs. arbitrary gestures (e.g., dropping motion for a rabbit). Experiment 2 replicated this comparison with 4-year-olds. All ages successfully mapped iconic gestures. Eighteen-month-olds and 4-year-olds but not 26-month-olds mapped arbitrary gestures, revealing a U-shaped developmental function. These findings imply that (a) there is no advantage for iconicity in early symbol learning and (b) the range of symbols mapped becomes more restricted at 26 months, re-emerging more flexibly during the preschool years. We argue that the decline in arbitrary gesture learning is a function of developing appreciation of communicative conventions. We propose that the re-emergence of arbitrary gestures at 4 years is driven by a wider range of symbolic experiences, and enhanced sensitivity to others' communicative intent.

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Traditional accounts of symbolic development (Piaget, 1962; Werner & Kaplan, 1963) and common sense suppose that iconicity—resemblance between a symbol and its referent—facilitates symbol acquisition in young children. To the extent that the relation between symbols and their referents are readily transparent, one might argue, children should more readily appreciate the representational and referential nature of the symbols. Indeed, iconicity has widely been regarded as such an advantage that many theorists dismiss iconic representations as true symbols (see, e.g., Peirce, 1960). In these accounts, only to the extent that a signal-referent relation is entirely arbitrary can that relation be termed a symbolic one. Implicit in this definition is the belief that children (and adults) need not accomplish the same degree of cognitive work to make the symbolic mapping of an iconic symbol.

The notion that the resemblance between a symbol and its referent may ease the complexity of the mapping problem for young symbol users is appealing as a model of the origins of symbolic insight. Children may initially succeed at symbol mapping prior to an explicit, full-blown understanding of symbols and of cues to symbolic reference because the symbol's resemblance to its referent reminds the child of the correct referent category. Evidence supporting the notion that iconic symbols are acquired early in development comes from observational studies of symbolic play and gestural naming, and from experimental studies of symbol learning. For example, from a very early age, children spontaneously engage in symbolic play behaviors. Infants as young as 16 months may engage in pretend actions in which they employ one object as a substitute for another (Elder & Pederson, 1978; Jackowitz & Watson, 1980; McCune-Nicholich, 1981). Early on, these symbolic play episodes almost exclusively involve the use of a highly similar object substitute, such as pretending to talk on a toy telephone. Only later do children begin to substitute objects that are dissimilar from the objects they are being used to represent, such as pretending to talk on a banana (Casby & Corte, 1987; Striano, Tomasello, & Rochat, 2001; Ungerer, Zelazo, Kearsley, & O'Leary, 1981). Thus, the resemblance between the substitute and the original seems to facilitate the use of an object as a symbol.

Acredolo and Goodwyn (1985, 1988; Goodwyn & Acredolo, 1993) have found that infants often use symbolic gestures that are extracted from familiar motor routines to label and request objects (e.g., a spider crawling motion derived from the Itsy-Bitsy Spider song that is used to name spiders). The vast majority of these early gestural symbols resemble some characteristic action or feature of the referents they depicted. Tomasello, Striano, and Rochat (1999) examined children's interpretations of iconic gestures as symbols in an experimental task at 18 and 26 months. They used iconic gestures to label objects (such as an empty handed hammering motion to label a hammer) and subsequently tested children's comprehension of these iconic gestures by asking them to select the object depicted by the gesture from an array of objects including the target object (the hammer) and several unrelated distractors. They reported that children readily mapped iconic gestures to objects at both 18 and 26 months of age, displaying no developmental change in the ability to interpret iconic symbols.

Although this evidence indicates that children readily learn iconic symbols, several empirical findings challenge the claim that there is any advantage for iconic symbols early in acquisition. The most salient counter-example to the claim that there is an advantage for iconic over arbitrary symbols is the precocity of children's early word learning. Children acquire their first words as early as 12 to 13 months of age and are able to map new arbitrary words to their referents after very few exposures (see, e.g., Woodward, Markman, & Fitzsimmons, 1994). A second piece of counter-evidence comes from recent analyses of the origins of children's early symbolic gestures. These studies reveal that the iconicity of the symbolic gestures children tend to employ may be simply an artifact of the type of gestures that parents tend to employ in everyday interactions with their infants (Acredolo & Goodwyn, 1988; Namy, Acredolo, & Goodwyn, 2000). That is, children extract and reproduce as symbols the gestures that parents use to augment their verbal communication. Thus, the preponderance of iconic gestures in the early lexicon may not imply an appreciation for or advantage of iconic gestures. Rather, this preponderance may merely reflect the composition of the gestures in the input. Indeed, Brown (1977) argued that there is no advantage of iconic over arbitrary symbols because young children lack the semantic knowledge that would enable them to link an iconic symbol with its referent (see also DePaul & Yoder, 1986; Dunham, 1989).

Additional evidence that symbol acquisition is not necessarily facilitated by iconicity comes from the study of natural sign language acquisition. Although sign languages include many iconic signs, a number of studies of deaf children acquiring sign from native signing parents indicate that children's earliest signs are not necessarily those that are most iconic (Klima & Bellugi, 1979; Meier, 1987; Morford, Singleton, & Goldin-Meadow, 1995; Newport & Meier, 1985; Orlansky & Bonvillian, 1984). For example, Orlansky and Bonvillian found that the degree to which a particular sign resembles its referent was not predictive of the age at which children acquire it. In another very strong case against iconicity facilitating early symbol acquisition, Petitto (1987) found that deaf children's mastery of pointing as a form of non-symbolic reference has little influence on their ability to use pointing as linguistic signs to indicate "you" and "me" in American Sign Language. Although children clearly master the ability to indicate themselves and others through pointing prior to the onset of symbolic communication, there is little transfer of this mastery into the symbolic domain.

Finally, recent findings from experimental studies of symbol learning reveal that very young children are surprisingly flexible in the range of symbols that they will accept as object names. For example, Namy (2001) recently introduced 18-month-old children to a range of different symbolic media as names for object categories, all of which were arbitrarily related to their referents, including words, gestures, non-verbal sounds, and pictograms. She found that children reliably mapped each of these symbolic forms to the object categories, interpreting all four symbol types as object names. Similar phenomena have been observed in numerous other studies comparing non-verbal to verbal stimuli (see, e.g., Hollich, Hirsh-Pasek, & Golinkoff, 2000; Namy & Waxman, 1998, 2000; Roberts, 1995; Roberts & Jacob, 1991; Woodward & Hoyne, 1999). Namy and colleagues (Campbell & Namy, 2003; Namy, 2001; Namy & Waxman, 1998, 2000) have argued that there is no clear advantage for any particular symbolic form over another at the onset of symbol acquisition. Rather, any symbolic form embedded in a familiar naming routine will be mapped to its referent, regardless of the modality or iconicity of the symbolic form.

Each of these findings indicates that children are good at learning both iconic and arbitrary symbols early in development, displaying no clear advantage for iconic symbols. In fact, there is some evidence that young children's symbol learning may even be hindered by a heightened degree of iconicity. For example, DeLoache (1991) finds that 30-month-old children have difficulty reasoning about a spatial location in a room from a 3-dimensional scale model, although they can reason from a location depicted in a picture. DeLoache has suggested that scale models are challenging for young children because they have difficulty simultaneously representing a 3-dimensional object as both an object and a symbol. DeLoache refers to this difficulty in construing an object as both an object and a symbol as the "dual representation" problem. Tomasello et al. (1999) reported a similar difficulty in using objects as symbols at 18 and 26 months in a simple object naming task. Children at both ages failed to interpret a small object replica as a symbol for the target object it depicted. Romski, Sevcik, and their colleagues (Romski, Sevcik, & Pate, 1988; Sevcik, Romski, & Wilkinson, 1991) have also suggested that the use of iconic symbols in augmentative communication systems among young children with language delay or cognitive disabilities may have a detrimental effect related to dual representational difficulties. More specifically, they argued that the use of arbitrary symbols enables children to more readily differentiate symbols from their referents.

Although many of these studies raise the possibility that iconicity may not facilitate early symbol acquisition, there is little experimental evidence to date that directly assesses children's use of iconicity in symbol acquisition. However, a comparison of two recent experiments sheds some indirect light on this issue. As described above, Tomasello et al. (1999) tested children's interpretation of iconic gestures at 18 and 26 months. An experimenter showed children a series of objects while modeling gestures based on a canonical action associated with each object. The experimenter subsequently used the associated gesture to indicate which object she wanted the child to select from the array to drop down a chute. Tomasello et al. found little developmental change in children's ability to identify the intended target. At both ages, children readily mapped the gesture to the target object.

Namy and Waxman (1998) recently tested children's ability to interpret novel arbitrary gestures as names for objects, coincidentally testing precisely the same two ages as did Tomasello et al. Namy and Waxman (1998) administered a task in which an experimenter presented pairs of objects from a target category (e.g., fruit) and labeled the instances using either a novel word or a novel gesture that was arbitrarily related to the object category. The experimenter subsequently presented a series of trials in which children saw a triad of objects that included one of the original objects, a novel member of the target category, and an unrelated distractor. After re-labeling the original object with the novel symbol, the experimenter asked the child to select another object (either the novel category member or the unrelated distractor) that bore the same name as the original object. Namy and Waxman documented an interesting developmental change in children's performance on this task; 18-month-olds readily extended both novel words and novel arbitrary gestures to additional members of the target category, whereas 26-month-olds extended only novel words to the target category, failing even to map arbitrary gestures to the original target objects. This "inverse" developmental trend suggested that there is some developmental reorganization in children's interpretations of non-verbal symbols between 18 and 26 months. Namy and Waxman (1998) argued that this developmental change is tied to children's increasing reliance on language as their primary communicative tool over development.

Although the methodologies were rather different in these two studies, a comparison of the outcomes of these experiments suggests that developmental change in children's ability to interpret gestural symbols may be characterized by a shift in children's attention to iconicity. At 18 months, children successfully mapped both arbitrary (Namy & Waxman, 1998) and iconic (Tomasello et al., 1999) gestures to their referents. At 26 months, children successfully mapped iconic gestures to their referents (Tomasello et al., 1999) but failed to map arbitrary gestures (Namy & Waxman, 1998). This outcome raises the intriguing and counterintuitive possibility that children may rely more on iconicity as a source of information about the meaning of nonverbal symbols later in development than at the onset of symbolic development. This indirect comparison reveals potential developmental reorganization in children's expectations about the forms that symbols (in particular, object names) can take. The goal of the current experiments was to directly examine the influence of iconicity on the acquisition of novel symbols. In Experiment 1, we compared children's acquisition of iconic versus arbitrary symbols at two discrete points in development, 18 and 26 months. The central hypothesis was that iconicity would be less likely to facilitate symbol-to-referent mapping early in development than at a later point in development. That is, we predicted that 18-month-olds would be equally successful at acquiring both arbitrary and iconic symbols. In contrast, we predicted that 26-month-olds would successfully acquire iconic symbols, but would fail to map arbitrary symbols to their referents. Experiment 2 examined the role of iconicity at an even later point in development. In this experiment, we tested 4-year-olds' interpretation of iconic and arbitrary symbols. We predicted that at 4 years of age, children's aquisition of arbitrary symbols would re-emerge as they became more attuned to communicative and referential intentions of others. Overall, we predicted continuous success at the learning of iconic symbols, throughout development. However, we predicted a U-shaped developmental trajectory for arbitrary symbols as children first acquired more specific and stringent expectations about the forms that a symbol may take, and then became more flexible again, as they developed an increased appreciation of the communicative and referential intentions of others. The direct comparison of these developmental trajectories for iconic and arbitrary symbols provides insights into children's shifting representational understanding of and expectations about symbols that neither symbolic form could reveal on its own.

In these experiments, we compared children's ability to learn arbitrary versus iconic gestures as symbols. We assessed children's success at mapping gestures to objects using a "finding" game, in which children were introduced to a symbol for a target object, and then were asked to select the object corresponding to the symbol from a pair of objects consisting of the target object and an unrelated distractor. For each target object, children participated in two types of trials, target trials and control trials. On target trials, the experimenter asked the children to find the target object using the previously introduced gesture. On control trials, the experimenter simply asked the child to pick an object, without using a symbol. This within-subject manipulation enabled children to serve as their own controls and also enabled us to discern the nature of the influence that gestural labeling had on children's cognitive processing. If the children mapped the gestures to their referents, they should select the target object reliably on target but not control trials. In contrast, if the act of gestural labeling merely heightened children's attention to the target object, children may reliably select the target object on both target and control trials.

EXPERIMENT 1

The first experiment was an assessment of 18- and 26-month-olds' mapping of gestural symbols to objects when those symbols were iconically versus arbitrarily related to their referents.

Method

Participants

Forty 18-month-olds (mean age = 17.87, median = 17.83, range = 17.04–18.95) and forty 26-month-olds (mean age = 25.92, median = 25.76, range = 25.07–27.53) from the greater Atlanta area participated in this study. Participants were from predominantly White or Black middle class families who were recruited via direct mailings. We also developed a stringent inclusion criterion for this and the subsequent study, including data only from those participants who made a clear choice on at least six of the eight trials (see below). An additional nine 18-month-olds (four in the iconic condition and five in the arbitrary condition) and three 26-month-olds (two in the iconic condition and one in the arbitrary condition) were excluded from the analysis due to failure to make enough clear choices.

Stimuli

Stimuli consisted of six small plastic toy replicas including a dog, a shoe, a car, a rabbit, a hammer, and a spoon. The dog and the shoe were used as training objects. The car, rabbit, hammer, and spoon were used in the experiment proper. All six objects were selected to be highly familiar to children at both ages. Indeed, to control for familiarity with the objects, their names, and their distinctive actions, we selected objects for which children tended to have a name prior to 18 months, as indexed by the Macarthur Communicative Development Inventory normative data (Fenson et al., 1994). Pilot testing to observe children's free play with these objects also indicated that children at both ages were highly familiar with the distinctive actions for each object on which we based the iconic gestures, as evidenced by their spontaneous play.

The symbolic stimuli, including both the iconic and arbitrary gestures used to label each object, are described in Table 1.

Gesture selection. For each object, we selected an iconic gesture derived from the familiar canonical motor action typically performed with these objects. In the strictest sense (see Peirce, 1960), the term "iconic" refers to those symbols that depict physical characteristics of their referents (such as the whiskers of a cat or the shape of a ball), whereas the term "indexic" refers to any symbol that resembles an action of the referent or activity associated with the object (such as the hopping motion of a rabbit or the stirring motion of a spoon). We use the term "iconic" in a more general sense to encompass both iconic and indexic symbols. Because the "iconic" gestures employed in these studies were actually derived from a specific actions associated with the objects, they are more like Peirce's indexic than iconic symbols. However, these indexic gestures are more like those that children are learning at these ages (see, e.g., Acredolo & Goodwyn, 1988).

To confirm that the gestures designated as "iconic" were more similar to their referents than the gestures designated as "arbitrary," we asked adult raters to assess how well the symbols represented their referents. A group of 13 undergraduate raters were asked to compare each of the eight gestures selected (four iconic and four arbitrary) to each of the four objects, and to rate on a 5-point scale how similar the gesture were to each object (with 5 corresponding to "extremely similar" and 1

TABLE 1
Description of Iconic and Arbitrary Gestures Employed for Each Object

	Gesture	
Object	*Iconic*	*Arbitrary*
Car	back and forth rolling motion, palm down, hand arched as if holding a car between fingers and thumb	repeated simultaneous extension of index and middle finger from a closed fist
Rabbit	repeated hopping motion, index and middle finger extended from closed fist like rabbit ears	side-to-side motion, hand extended as if to shake hands
Hammer	repeated up and down motion with closed fist as if banging a hammer	dropping motion with closed fist opening, palm down
Spoon	closed fist moved repeatedly toward face, as if bringing a spoon to the mouth	closed fist with thumb and pinky finger extended, rocking side-to-side

corresponding to "not at all similar"). Thus, each symbol was presented paired with one object that was designated its referent object (which in the case of the iconic symbol was intended to resemble the referent and in the case of the arbitrary symbol was not) and was also paired with three non-referent objects that were not associated with the symbol during the experiment proper. Raters were given no specific information about the purpose of the rating task, and gesture-object pairings were presented in a random order.

We performed a 2 × 2 analysis of variance (ANOVA) with gesture type (iconic vs. arbitrary) and object (referent vs. non-referent) as within-subject variables. Main effects of gesture type and object, Fs(1, 12) = 426.41 and 323.50, respectively, both ps < .001, were mediated by a Gesture Type × Object interaction, Fs(1, 12) = 323.50, $p < .001$. Post hoc analyses (Tukey's HSD, $p < .05$) indicated that raters perceived the iconic gestures as reliably more similar to their referents (M = 4.65, SD = 0.46) than were the arbitrary gestures (M = 1.48, SD = 0.39). Furthermore, the iconic gestures were judged as reliably more similar to their own referents (M = 4.65, SD = 0.46) than to the other three stimulus objects (M = 1.41, SD = 0.34) whereas arbitrary gestures were not judged as reliably more similar to their referents (M = 1.48, SD = 0.39) than to the other three stimulus objects (M = 1.41, SD = 0.30).

Design of Experiment Proper

In this experiment, children at each age were randomly assigned to either the arbitrary or iconic condition. The experimental procedure was identical in the two conditions, with the exception of the type of gesture employed. Children were tested on two sets of objects. For each set, the experimenter labeled one object in the pair (the target object) several times, and drew attention to the other object in the pair (the distractor) an equal number of times. For each set, she then administered two target trials (in which the children were asked to select the object associated with the target gesture) and two control trials (in which children were simply asked to pick an object). Thus, children completed a total of eight trials including four target trials and four control trials. Hence, the experimental design was 2 (age: 18 vs. 26 months) × 2 (condition: arbitrary vs. iconic) × 2 (trial type: target vs. control) with age and condition as between-subject variables, and trial type as a within-subject variable.

Procedure

We assessed children's success at mapping a particular symbolic form to an object using a "finding" game. During a warm-up period, the children learned to retrieve a specific familiar object from a pair of familiar objects at the experimenter's request (e.g., "Can I have the doggie?" or "Now get the shoe!") Children received reinforcement (i.e., clapping and cheering) for selecting the correct object. The experiment proper was divided into two phases, an introduction phase and a test phase.

Introduction phase. For each child, the four toys were divided into two pairs. Which objects were paired, and which pair was presented first were randomly determined for each child, using a random number generator. After the warm-up period, the experimenter presented the two objects from the first set (e.g., a hammer and a rabbit) one at a time, and permitted the children to play freely with them. During play, the experimenter drew attention to each toy approximately five times. She labeled one object, the target object, with a novel symbol each time she referred to it (e.g., pointing to the hammer and saying "Look at this! [hammering motion]" in the Iconic condition or "Look at this! [dropping motion]" in the arbitrary condition). For the other object, the distractor, she simply drew attention to it, without using a symbol (e.g., pointing to the rabbit and saying "Look at what I have!"). To control for any possible effects of particular items or of order of presentation, we randomly selected which objects would be the target in each pair for each child, and also randomly varied whether the target or the distractor would be presented first for each child.

Test phase. The experimenter then administered a series of four forced-choice trials in which she presented the pair of objects and asked the child to select one of the toys. On two of the four trials, the target trials, the experimenter asked the child to demonstrate her knowledge of the symbol-to-referent mapping, saying, for example, “Which one can you get? [performs hammering motion] Can you get it?” Pilot testing indicated that this wording appeared to elicit a choice from the children most reliably. By indicating that a choice needed to be made before the gesture was performed, we minimized the number of trials on which children selected neither object or both. This wording had the additional advantage that it did not require embedding the gesture within a spoken sentence, which is less natural and familiar to young children. On the remaining two trials, the control trials, the experimenter used similar wording without using a gesture, asking, “Which one can you get? Can you get one?” Order of presentation of the test and control trials was randomly assigned for each child. After administering four trials for the first pair of objects, the experimenter repeated the introduction and test phase a second time with the remaining two objects (e.g., the car and the spoon), introducing a novel symbol for one of them and then administering an additional four forced-choice trials for the second pair of objects.

This task has been effective in evaluating young children’s symbol comprehension in the past (see, e.g., Woodward & Hoyne, 1999; Woodward, Markman, & Fitzsimmons, 1994) and has the additional advantage of allowing the children to serve as their own controls. Success on this symbol-mapping task was determined by comparing the likelihood of selecting the target object when prompted on the target trials to likelihood of selecting the target object on control trials.

Coding

Choice coding. A primary coder analyzed videotapes of all 80 children to determine whether the children selected the target object, distractor, neither, or both on each trial. A coding classification of “no choice” was made if a child selected both objects simultaneously or in quick succession, or if the child failed to select either object during the test trial. A child’s response was classified as a choice if she touched or picked up one object, or handed one of the two objects to the experimenter. Trials on which children made no choice were excluded from the analysis. Children who made no choice on more than two trials were excluded from the experiment (see Participant information, above). A second coder blind to the experimental hypotheses analyzed a randomly selected 20% of the children in each condition at each age. Inter-coder agreement on individual trials was 96.25%.

Gesture production coding. A third coder, blind to the experimental hypotheses, tallied the number of times each child attempted to produce or imitate the target gesture produced by the experimenter. Although the experimenter did not ever elicit gesture production, the children occasionally spontaneously imitated the gestures. This measure is an imperfect indicator of children’s understanding of the gestures because lack of production does not imply lack of comprehension, and even those children who produced the gestures may not necessarily have understood their symbolic nature. But, to the extent that the patterns of production behavior mirror the comprehension measures collected from the forced-choice task, this measure will bolster the trends observed. For this exploratory analysis, we counted any empty-handed attempt at imitation of the target gesture that approximately followed the handshape and hand/arm trajectory of the target gesture.

Results

The outcome of this study confirms our prediction that iconicity plays a relatively greater role in symbol-mapping at 26 months than at 18 months. Preliminary analyses indicated that there were no reliable effects of individual items or of particular item pairings on performance. As a result, all analyses are presented collapsed across items. Using a 3-way ANOVA with age (18- vs. 26-month-olds) and condition (iconic vs. arbitrary) as between-subjects variables and trial type (target vs. control) as a within-subject variable, we assessed children's success at mapping symbols to the target objects. Mean performance on target and control trials in each condition at each age is depicted in Table 2. The ANOVA indicated no main effects of condition or age, but revealed a main effect of trial type, $F(1, 76) = 13.49$, $p < .001$, indicating that children selected the target object more often on target trials than on control trials. There was also a Trial Type × Age interaction, $F(1, 76) = 4.69$, $p < .05$, mediated by a three-way interaction among trial type, age, and condition, $F(1, 76) = 4.69$, $p < .05$. Post hoc analysis of this interaction (Tukey's HSD, $p < .05$) indicated that, as predicted, 18-month-olds selected the target object reliably more often on the target trials than on the control trials in both the iconic and the arbitrary condition. In contrast, 26-month-olds selected the target more often on tar-

TABLE 2
Mean Proportion Target Responding (and Standard Deviation) for Iconic and Arbitrary Gestures on Target and Control Trials at Each Age
(n = 20 per Condition at Each Age)

	Condition			
	Iconic		*Arbitrary*	
	Target	*Control*	*Target*	*Control*
18 months	.66*	.49	.64*	.43
	(.33)	(.27)	(.33)	(.29)
26 months	.65**	.48	.51	.59
	(.25)	(.23)	(.31)	(.28)
4 years	.85**	.43	.83**	.41
	(.21)	(.22)	(.26)	(.19)

* above chance, $p < .05$, 1-tailed. ** above chance, $p < .005$, 1-tailed.

get than control trials in the iconic condition, but failed to select the target more often on target trials in the arbitrary condition. That is, 18-month-olds succeeded at the gesture mapping task in both the iconic and arbitrary conditions, whereas the 26-month-olds succeeded only in the iconic condition.

The above analysis was augmented by comparing performance for each trial type to chance (.50). Individual t tests indicated that 18-month-olds selected the target object at above chance rates on target trials in both the iconic and arbitrary conditions, $ts(19) =$ 2.22 and 1.87, respectively, both $ps < .05$, 1-tailed. Their responses did not differ from chance for control trials in either condition. In contrast, 26-month-olds performed above chance responding for target trials in the iconic condition, $t(19) = 2.70, p < .05$, 1-tailed, but did not differ from chance on target trials in the arbitrary condition. In both conditions, 26-month-olds did not differ from chance performance for control trials. These findings mirror the findings from the ANOVA; children successfully mapped the gesture to the target object at 18 months in both conditions, but only mapped the gesture to the target in the iconic condition at 26 months.

We also performed an analysis of individual patterns of responding, assessing the number of children who selected the target object more often on target trials than on control trials. See Figure 1. In the iconic condition, there was no developmental difference in the number of children adhering to this pattern. However, in the arbitrary condition, there was a developmental difference. Significantly more children were successful at mapping arbitrary gestures to objects at 18 months than at 26 months, Fisher's exact test, $p = .01$.

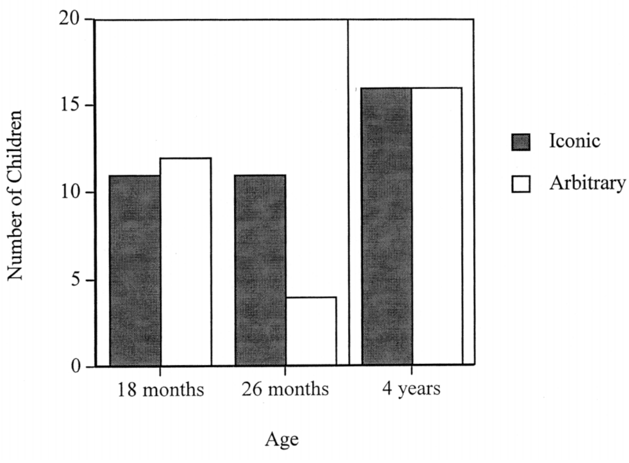

FIGURE 1 Number of children selecting target objects more often on target than control trials in each condition at each age ($n = 20$ per cell). Experiment 1 reports 18- and 26-month-olds' performance and Experiment 2 reports 4-year-olds' performance.

Finally, we sought converging evidence for this developing priority for iconic over arbitrary gestures from children's spontaneous imitations of the target gestures during the procedure. We conducted a 2 (Age) × 2 (Condition) ANOVA on the frequency of target gesture production, and found an Age × Condition interaction, $F(1, 76) = 3.99$, $p < .05$. Post hoc analysis (Tukey's HSD, $p < .05$) revealed that 18-month-olds were equally likely to produce the iconic and arbitrary gestures ($M = .40$ and $.50$ gestures produced respectively, SDs = 0.94 and 1.10.) In contrast, 26-month-olds were more likely to produce iconic than arbitrary gestures ($M = 1.50$ and $.30$ gestures produced, respectively, SDs = 2.33 and .98). This effect strengthens the claim that iconicity facilitates symbol learning at 26 months but not at 18 months.

Discussion

These data indicate that at 18 months, children map both arbitrary and iconic gestures to objects with equal ease, whereas at 26 months, children map only iconic gestures to objects. Children's success at learning both arbitrary and iconic symbols at 18 months combined with their more limited acquisition of only iconic gestures at 26 months implies that there is no advantage for iconic over arbitrary symbols early in development. Rather, this finding would suggest that iconicity only eases the symbolic mapping process later in development. The developmental divergence between iconic and arbitrary symbols provides further evidence (see Namy & Waxman, 1998; Woodward & Hoyne, 1999) for developmental reorganization of children's symbolic abilities between 18 and 26 months. With development, children seem to acquire more conservative expectations about the form that a symbol may take. Past work suggests that an initial, general ability to learn symbols gives rise to a more focused tendency to use words as the predominant symbolic modality, as children's appreciation of the unique aspects of language (e.g., syntax) develops. The current finding reveals that 26-month-olds readily learn gestures as symbols but only when some prior association between the gesture and their knowledge of what one does with the object is present. Other research (see, e.g., Graf, 2001; Namy & Waxman, 1998, Experiment 3) suggests that other cues such as explicit training, or additional linguistic information also release children from their conservative expectations, enabling them to map non-verbal or unconventional symbols to their referents.

The developmental difference in children's apparent benefit from iconicity at 18 versus 26 months has three important implications. First, these findings suggest that iconicity does not play a critical role in the early acquisition of symbols. Eighteen-month-olds were equally likely to map arbitrary or iconic gesture to objects. This is consistent with previous studies indicating that young children have few specific expectations about the form that an object name can take (Namy, 2001; Namy & Waxman, 1998; Woodward & Hoyne, 1999). Second, these findings reveal that children's expectations about the range of conditions under which a gesture can name an object change over development—26-month-olds learned gestures under a more restricted set of circumstances than their younger counterparts. Third, these data highlight that although 26-month-olds are reluctant to interpret a gesture as a symbol (as was found by Namy & Waxman, 1998), they readily learn gestures when the experimenter transparently signals her intention to refer to the object by using a gesture that resembles familiar actions that are routinely performed with the object.

The developmental decline in children's performance in the arbitrary condition is all the more striking given the lack of developmental change in children's performance in the iconic condition. A study of iconic gestures alone would have revealed neither the developmental change in children's representations nor the relative lack of influence iconicity plays in 18-month-olds' gesture mapping. Given the familiar and salient referential cues present in the introduction phase, and the reliable co-occurrence of the object and gesture, why would 26-month-olds seemingly inhibit mapping arbitrary gestures to objects? We argue that this is an important phase in children's symbolic development in which they must narrow and specialize their symbolic expectations in order to direct their attention to regularities in the language system and in communication as a whole. However, we predict that this is not a permanent state of affairs for young children. We propose that the inhibition of arbitrary gestures relative to iconic gestures would not be evident in even older children for whom the acquisition of symbols and use of referential cues have become quite practiced and familiar. In the following experiment, we test this hypothesis, comparing 4-year-old children's ability to map arbitrary and iconic gestures to objects.

EXPERIMENT 2

This experiment replicates Experiment 1 with 4-year-old children. We predict that this age group will readily map not only the iconic but also the arbitrary gestures to their referents. If so, this would reveal a second developmental shift in children's symbolic development, indicating that the conditions under which children accept gestures as symbols changes as they acquire a greater range of symbolic experiences and better understanding of cues to intentional communication in others.

Method

Participants

Forty 4-year-olds (mean age = 53.26 months, median = 53.96, range = 44.57–59.51) from the greater Atlanta area participated in this study. Participants were from predominantly White or Black middle class families who were recruited via direct mailings and local preschools. As in the previous experiment, only those participants who made a clear choice on at least six of the eight trials were included in the analysis. An additional four 4-year-olds (three in the iconic condition and one in the arbitrary condition) were excluded from the analysis: one due to video equipment failure, one due to a side preference on all 8 trials, and two due to failure to complete the procedure.

Stimuli and Procedure

Stimuli and procedure were identical to those used in Experiment 1. The coding scheme was also identical. A primary coder analyzed all children's sessions. A secondary coder analyzed a randomly selected 20% of the sessions in each condition. Inter-coder agreement on individual trials was 98%.

Results

The outcome of this study confirms our prediction that 4-year-olds recover the ability to map arbitrary gestures to objects, revealing a U-shaped developmental trajectory for the acquisition of arbitrary gestures. Using a two-way ANOVA with condition (iconic vs. arbitrary) as a between-subject variable and trial type (target vs. control) as a within-subject variable, we assessed 4-year-olds' success at mapping symbols to the target objects. Mean performance on target and control trials in each condition at each age is depicted in Table 2. The ANOVA revealed only a main effect of trial type, $F(1, 38) = 62.49, p < .001$, indicating that children selected the target object more often on target trials than on control trials. There was no effect of condition and there were no significant interactions. Thus, 4-year-olds succeeded at the gesture mapping task in both the iconic and arbitrary conditions.

As in Experiment 1, we also compared performance for each trial type to chance (.50). Individual t tests indicated that 4-year-olds responded at above chance levels for the target trials in both the arbitrary and the iconic condition, ts(19) = 7.63 and 5.63, respectively, ps < .005, 1-tailed. Responses did not differ from chance performance on control trials in either condition. These findings reveal that children's expectations about symbolic forms have changed since 26 months, such that they now readily accept arbitrary gestures.

We also performed an analysis of individual patterns of responding, assessing the number of children who selected the target object more often on target trials than on control trials, see Figure 1. There was no difference in the number of children fitting this pattern in the two conditions, Fisher's exact test, $p = .305$.

Discussion

This examination of 4-year-olds' interpretation of iconic and arbitrary gestures revealed that this age group successfully mapped both symbolic forms to their referents. Thus, although the ability to learn iconic gestures remains constant over development, the learning of arbitrary gestures, which declines at 26 months, is recovered by 4 years of age. We argue that this re-emergence of arbitrary gestures is a function of a wider range of symbolic experiences, an enhanced understanding of the cues that signal communicative intentions of others, and perhaps a more explicit awareness of symbolic relations (see, e.g., Karmiloff-Smith, 1992). This greater experience and greater sophistication of understanding may manifest itself as a greater flexibility and willingness to accept unconventional symbols, given the familiar naming routine in which they were embedded.

GENERAL DISCUSSION

Taken together, these two experiments yield a striking developmental shift in the relative advantage of iconic over arbitrary symbols. In Experiment 1, 18-month-olds successfully mapped both arbitrary and iconic symbolic gestures to objects, whereas 26-month-olds mapped iconic, but not arbitrary gestures to objects. In Experiment 2, 4-year-olds, like 18-month-olds, successfully mapped both arbitrary and iconic gestures to objects. Thus, although iconic gestures were readily mapped across all three age groups, arbitrary gestures underwent a U-shaped developmental trajectory. These patterns indicate that iconicity does not facilitate the early acquisition of symbolic development and that children's expectations about the meaning of symbolic gestures undergo several phases of representational change, as children's understanding of symbols and communicative conventions develop.

Implications Regarding the Role of Iconicity in Early Symbol Acquisition

These findings challenge traditional models of symbol acquisition that suggest iconicity eases the symbolic mapping process for young children. Although most of children's early gestural symbols are iconically related to their referents (see, e.g., Acredolo & Goodwyn, 1988), this may be largely an artifact of the type of symbols to which children are typically exposed early in development (Namy, Acredolo, & Goodwyn, 2000), rather than because they are most comprehensible. The current findings suggest that it is only later in development that children more readily learn iconic than arbitrary symbols.

There are at least three possible explanations for why iconicity might not facilitate symbol acquisition at the onset of symbolic development. First, as Bates, Benigni, Bretherton, Camaioni, and Volterra (1979) suggested, perhaps iconicity does not influence early symbol acquisition because younger children simply fail to apprehend the similarity between the symbol and its referent. A second explanation is that older children might benefit more from iconicity than younger children because older children are more familiar with the particular, conventionalized, iconic symbols (such as hand-flapping to indicate a bird) that are typically used within the child's culture. Because older children have had more exposure to the iconic symbols employed in their culture, they may more readily associate the symbols with their referents, independent of the resemblance between the symbol and its referent. This would imply that the benefit is not due to iconicity per se. However, Namy (2004) recently demonstrated that similar effects of iconicity are observed for gestures derived from novel actions performed on novel objects, suggesting that it is iconicity and not conventionality that drives this effect. Third, there may be developmental change in children's attention to and willingness to use iconicity to guide symbol interpretation. Perhaps early in development, children perceive the iconic relation between symbols and their referents but are more attentive to other cues such as the social-referential context in which symbols occur as indicators of the mapping between symbol and referent, for example. We cannot, on the basis of these data, determine which of these explanations best accounts for the data. But the clear implication of any of these accounts is that iconicity does not guide the discovery of symbolic development.

Although iconicity does not appear to provide an advantage for symbol learning at the onset of symbol learning, iconic symbols are privileged by 26 months. As demonstrated in Experiment 1 and in previous work (Namy & Waxman, 1998), 26-month-olds less readily map arbitrary gestures to object categories than they do words or iconic gestures. Put another way, 26-month-olds inhibit the acquisition of arbitrary gestures relative to iconic gestures and relative to younger and older children. Namy and Waxman have argued that an initial, general ability to learn symbols (both words and gestures) develops into a more focused tendency to use words as the predominant form of referential communication.

How do we know that 26-month-olds regard iconic gestures as symbols at all? Perhaps 26-month-olds succeeded in the iconic condition simply because the gestures reminded them of what they do with the target objects. Indeed, we have argued that association between the object and the gestural representation of its canonical action is precisely what releases 26-month-olds from their gesture inhibition. It is possible that 26-month-olds are performing solely on the basis of this association and reminding without necessarily making a symbolic mapping. However, the gesture is at least one step removed from the object in that it is a representation of and not a literal performance of the action with object in hand, and in that sense it may be symbolic. We cannot, on the basis of the existing data, rule out the possibility that 26-month-olds are not performing a symbolic mapping at all. Whereas there is a great deal of converging evidence from production and comprehension studies that 18-month-olds interpret and employ gestures symbolically (Acredolo & Goodwyn, 1985, 1988; Campbell & Namy, 2003; Goodwyn & Acredolo, 1993; Namy, 2001; Namy & Waxman, 1998, 2000; Tomasello, Striano,

& Rochat, 1999), it is not clear whether success of 26-month-olds in the iconic condition can be attributed to symbolic understanding. In any case, it is clear that iconic gestures elicit selective responding to the target whereas the reliable association between the arbitrary gesture and target within the experiment elicited no such responding.

Although iconicity appears to serve an important function in overcoming 26-month-olds' scruples regarding gesture mapping, by 4 years of age children appear to have no such reservations. As a result, arbitrariness no longer appears to inhibit gesture learning at 4 years of age. This may be a function of the increasingly more sophisticated understanding of adult cues to intention, as well as increased experience with the conventional (often arbitrary) forms of symbolic reference typically employed in our culture. By 4 years of age, children may have reached a more explicit or abstract level of understanding of how people signal their intention to label, rendering them highly adaptable to various symbolic forms provided sufficient cues to labeling are present.

Implications of a U-shaped Developmental Function

The U-shaped trajectory of arbitrary gesture learning captures an important shift in children's conceptualization of symbols. This would not have been evident had we studied only infants and preschoolers, without testing the intermediate toddler age. The performance of 26-month-olds reveals that the nearly identical performance of 18-month-olds and 4-year-olds does not imply identical process. Indeed, this U-shaped developmental function for arbitrary gestures, in conjunction with the lack of developmental change for iconic gestures, provides important insight into how children's symbolic understanding is changing over development.

At 26 months, children have developed more rigid expectations than their younger counterparts about the forms that object labels may take. It appears that this developing rigidity is an important intermediate stage in children's symbolic development that drives children to begin to differentiate the communicative function of words from that of non-verbal symbols. We suggest that this differentiation is critical for children to begin to make inroads into the complexities of the linguistic system, moving beyond the initial phase of using individual symbols to represent ideas in a one-to-one fashion.

By the time children reach preschool age, the rigidity that characterized the 26-month-olds appears to be gone. This is a reasonable outcome given that children have, by 4 years of age, made substantial advances in linguistic mastery, and have also made significant advances in the use of other forms of symbols. For example, they begin to understand pictures, maps, and models as symbolic representations, they begin to comprehend visual symbols such as traffic lights and poison symbols, and they have even begun to appreciate the symbolic nature of written language. As a result, to the extent that the symbolic intentions of the symbol user is clear, preschool children appear to readily map either arbitrary or iconic symbols to their referents.

CONCLUSIONS

These experiments contribute importantly to our understanding of the factors driving early symbolic development. In conjunction with previous work on early symbol acquisition (Acredolo & Goodwyn, 1988; Hollich et al., 2000; Namy, 2001; Woodward & Hoyne, 1999) these studies support the claim that young symbol learners readily map a broad range of symbols to their referents, independent of the symbolic form, provided they are embedded in a social-referential naming routine. These studies also lend support to the argument that there is change in children's expectations about the form that symbols can take over development. Consistent with previous studies (Namy & Waxman, 1998, Woodward & Hoyne, 1999), these studies indicate that slightly older children are more conservative in the range of symbolic forms that they will accept. We suggest that as children develop a more sophisticated understanding of the conventions governing human communication, they begin to employ iconicity as an indicator that non-verbal symbols are intended to refer to the target objects. As they acquire even further experience and sophistication as symbol users, children's expectations about the form that a non-verbal symbol can take become less rigid again. We speculate that this redeveloping flexibility is a function of a more explicit awareness of how symbols work, a wider range of symbolic experiences, and an enhanced understanding of the communicative intentions of others.

ACKNOWLEDGMENTS

The work for this article was supported by NIH Grant MH61846-02. We thank Sandy Waxman for her input on the development of these studies and two anonymous reviewers for their constructive feedback on earlier drafts. We also thank Rebecca Fiscal and Rachel Robertson for their support and assistance.

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