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NOTE

Patterns of spontaneous production of novel words and gestures within an experimental setting in children ages 1;6 and 2;2*

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ABSTRACT

This study presents an analysis of children's spontaneous production of words and gestures during an experimental symbol learning task. Namy & Waxman (1998) previously reported that children aged 1;6 interpreted novel arbitrary words (e.g. blicket) and manual gestures (e.g. a dropping motion) as names for object categories (e.g. fruit) but that at 2;2, children interpreted words as names more readily than gestures. Based on this finding and other observational evidence of gesture use, it has been suggested that the younger infants have an initial general symbolic capacity that encompasses both words and gestures. Over time, as infants acquire greater experience with language, words begin to take on a greater priority in the infant's communicative repertoire. The current study examines this hypothesis by analyzing children's spontaneous production of the novel symbols in Namy & Waxman's original task. At 1;6, children rarely produced either the novel words or gestures. At 2;2, children frequently produced both symbolic forms; however, words were produced in a referential manner while gestures were produced in a non-referential manner. These findings are consistent with the argument that over time, words supplant gestures as a symbolic medium.

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INTRODUCTION

Infants have a powerful, early ability to learn names. Experimental paradigms have documented that infants as young as twelve months of age have the receptive capacity to map novel words to objects and object categories (Waxman & Hall, 1993; Woodward, Markman & Fitzsimmons, 1994; Waxman & Markow, 1995). When an adult labels an object with a novel word, such as 'blicket', infants systematically extend that word to other members of the same object category. At around this same age, infants begin to produce their first words, making initial strides towards truly symbolic communication.

In a recent series of studies, Namy & Waxman (1998) examined the range of symbols that infants interpret as names. These studies were based on a receptive paradigm. Children aged 1;6 and 2;2 were introduced either to novel words or to novel arbitrary gestures as object labels. Infants age 1;6 successfully mapped both words and gestures to object categories. Infants age 2;2 mapped words but NOT gestures to object categories. These data on infants' symbol comprehension are consistent with evidence from the production literature (Acredolo & Goodwyn, 1985, 1988; Goodwyn & Acredolo, 1993; Iverson, Capirci & Capelli, 1994) suggesting that young infants often produce symbolic gestures. In naturalistic studies, infants appear to extract gestures from familiar motor routines or action sequences (e.g. flapping hands for a bird or pointing to an open hand to request more). Up to 87% of infants employ these symbolic gestures, using them in much the same way that they use words (Acredolo & Goodwyn, 1988). These findings suggest that infants who are learning a spoken language initially accept both words and non-verbal symbols such as gestures (and indeed, other symbolic forms such as non-verbal sounds and pictograms, Roberts & Jacob, 1991; Woodward & Hoyne, 1999; Hollich, Hirsh-Pasek & Golinkoff, 2000; Namy, 2001) as names for object categories. These data also reveal a developmental trend in which younger infants are actually MORE flexible than older infants at learning symbols other than words.

Namy & Waxman (1998) argue from these data that infants possess an initial, general ability to learn symbols (both words and gestures) that develops into a more focused tendency in hearing infants to use words as the predominant form of referential communication. This equipotentiality of words and gestures in infants' early production may be related, at least in part, to the input they receive. Because parents frequently produce both verbal and gestural 'labels' for objects during the same joint-attention episode, young infants have no reason, on the basis of the input, to discriminate between adults' intentions when they produce words and their intentions when they produce gestures (Namy, Acredolo & Goodwyn, 2000).

Although the findings from spontaneous symbol production are consistent

with those observed in symbol comprehension (Namy & Waxman, 1998), the comprehension and production data differ in several potentially important ways. The gestural symbols produced by infants tend to be acquired naturalistically over long periods of time during which primary caregivers and their infants employed the gestures as part of their daily established routines (Acredolo & Goodwyn, 1985, 1988). In contrast, the novel arbitrary symbols comprehended by infants in Namy & Waxman's (1998) study were introduced during a single, brief experimental play session. It is unclear, therefore, whether this comprehension data captures the same phenomenon observed in children's spontaneous communication. Fortunately, the videotaped experimental sessions recorded by Namy & Waxman allow us to examine infants' spontaneous production of the novel symbols during the experiment. This provides the opportunity to assess whether the data collected within an experimental setting converge with that observed in naturalistic production.

The goal of this paper is to examine whether the developmental trend in infants' COMPREHENSION of the novel arbitrary symbols employed by Namy & Waxman is mirrored in their spontaneous PRODUCTION of the novel, arbitrary symbols introduced during this experimental paradigm. We therefore coded the videotapes of the infants age 1;6 and 2;2 originally analyzed by Namy & Waxman (1998), with an eye towards their spontaneous production of words and gestures. We were particularly interested in three measures: (1) the overall frequency of verbal and gestural production at each age, (2) the frequency of production of the NOVEL symbols presented by the experimenter during the session, and (3) whether the novel symbols were produced in a referential or non-referential fashion. The question of interest is whether infants' spontaneous symbol production reveals the same developmental pattern of divergence between words and gestures that has been found in infants' comprehension of symbols in this same paradigm (Namy & Waxman, 1998).

METHOD

Subjects

Thirty-two infants age 1;6 (mean age = 1;5·9, range = 1;4·8–1;6·6) and thirty-two infants age 2;2 (mean age = 2;1·9, range = 2;1·1–2;2·7) 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. The younger sample included only infants who were not yet combining words (according to parental report). The older sample included only infants who had begun to combine words (according to parental report).

Procedure

Infants participated in a forced-choice categorization task and were randomly assigned to learn either novel words or novel gestures as names for object categories. All symbols were arbitrarily related to their referents. In the experimental paradigm, infants were introduced to a total of three novel symbols, one at a time. Table 1 lists the novel symbols introduced in each

TABLE 1. *List of novel words and symbolic gestures*

Novel words	Novel gestures
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

condition. For each of the three symbols, there was an introductory play session during which the experimenter introduced the target symbol (word or gesture). During the course of this play session, which lasted approximately 45 to 60 sec, the experimenter produced the symbol a total of 10 times in reference to a member of the target category (e.g. fruit). Immediately following this naturalistic play session, the experimenter administered a series of six forced-choice categorization trials for each symbol. During the test period, which lasted approximately 3·5 to 4 min, the infants were shown a member of the target category (e.g. an apple) and were told, 'Look at this [*symbol*]!' They were then given two additional objects, including another member of the target category (e.g. a pear) and an unrelated distractor (e.g. a chair). They were asked, 'Can you find another [*symbol*]?' Thus, in the course of administering the test phase, the experimenter produced the novel symbols an additional 10 to 15 times. Importantly, at no point during the session were the infants required or invited to produce the novel symbols. Infants may have spontaneously produced these symbols in imitation of the experimenter, however, production of the target symbols on the part of the infants was never elicited. The sessions typically lasted approximately 12 to 14 minutes total. (See Namy & Waxman, 1998, Experiment 1, for a more complete description of the procedure and the infants' comprehension data.)

Coding

We coded the spontaneous verbal productions of infants in the Word condition and the spontaneous gestural productions of infants in the Gesture condition throughout the testing session, beginning when the experimenter presented the child with the first stimulus item and ending after the child had responded to the final test trial. Productions were classified either as TARGET

PRODUCTIONS or as OTHER PRODUCTIONS. Target productions included any recognizable imitation of the target words or gestures introduced during the experimental session. Other productions included any intentional communicative act occurring in the same modality as the target symbols. This included object labels, descriptions or comments, referential acts (e.g. pointing, saying 'Look') and other conventionalized acts (e.g. 'Yes', 'No', 'Bye-bye', waving, nodding, clapping).

We also recorded, for each target production, whether it had been produced referentially or non-referentially based on whether the infants in some manner indicated the object while producing the target symbol. We designed a conservative coding scheme, accepting only completely unambiguous cases as referential. The target was coded as referential if the infant pointed to or gazed at or held up the target object while she produced the target symbol. The target was coded as non-referential if the infant did not in any way attend to or indicate the object while producing the target. Based on pilot work and previous studies (e.g. Baldwin & Markman, 1989), we were reasonably confident that these criteria would provide a good indicator of referential understanding because children at a variety of ages consistently met these criteria when learning novel object names. Because we found that most children adhered to these criteria when producing novel words (particularly at age 2;2, an age at which children's appreciation of the symbolic and referential function of words is rarely disputed), we are able to use this measure as an index of whether the novel gestures were interpreted differently.

Additional coding criteria. There were several additional criteria used to code infants' productions. First, we excluded open-handed reaches as productions because we could not determine whether the child was reaching to indicate the object in a communicative manner or was reaching instrumentally in order to obtain the object. Second, when infants repeated utterances several times in succession, the verbal utterances were counted multiple times only when they were separated by a pause or break in the speech stream, and the gestural utterances were counted multiple times only if the child's hand relaxed, returned to the body, or dropped between repetitions. Third, symmetrical motions with both hands were counted as a single gesture.

Coding reliability. A single coder analyzed all 64 videotaped sessions. A secondary coder analysed a randomly selected 25% of the sessions in each condition at each age. Reliability was calculated based on whether the two coders both noted each production and agreed in their classification of each production as target or other. Inter-coder reliability was established separately for each condition at each age using the kappa statistic, all p's $< 0{\cdot}01$.

RESULTS AND DISCUSSION

We performed a series of analyses to examine infants' verbal and gestural productions at each age. First, we examined the total frequency of words and gestures in infants' spontaneous production (including both target production and other productions). Next, we examined the frequency specifically of target productions in the Word and Gesture condition at each age. Finally, we examined the proportion of target productions that were referential versus non-referential in each condition at each age.

Total frequency of verbal and gestural production. A (2) word vs. gesture × (2) age: 1;6 vs. 2;2 ANOVA on total production yielded a main effect of age, $F(1, 60) = 31{\cdot}90$, $p < 0{\cdot}001$. Not surprisingly, the older group produced more than the younger group. A main effect of condition, $F(1, 60) = 29{\cdot}22$, $p < 0{\cdot}001$, indicated that infants produced more verbal than gestural utterances. These main effects were mediated by an age × condition interaction, $F(1, 60) = 30{\cdot}10$, $p < 0{\cdot}001$. At age 1;6, infants produce words ($M = 9{\cdot}50$, S.D. = 14·71) and gestures ($M = 9{\cdot}88$, S.D. = 12·07) at comparable rates; at age 2;2, infants produced more verbal ($M = 61{\cdot}25$, S.D. = 30·96) than gestural utterances ($M = 10{\cdot}63$, S.D. = 7·87).

Although the older children produced many more words than gestures, this does not imply that gestures were an unimportant part of the communicative repertoire at this age. For although in the data reported here, words outstrip gestures six-fold at age 2;2, all 16 of the children in the Gesture condition produced gestures during the experimental session (range of gesture production = 2–27). Furthermore, developmental changes can be characterized by an INCREASE in word production (from 9·5 at 1;6 to 61·25 at 2;2) rather than a DECREASE in gesture production (remaining roughly constant from 9·5 at 1;6 to 10·63 at 2;2). This indicates that by the age of 2;2, words have become the dominant communication medium, with infants using gestures (such as points and nods) to augment their verbal communication.

Frequency of target production. We conducted a (2) word vs. gesture × (2) age: 1;6 vs. 2;2 ANOVA on the number of targets produced during the experimental session. This ANOVA yielded a main effect of age, $F(1, 60) = 4{\cdot}308$, $p < 0{\cdot}05$, indicating that infants were more likely to produce the targets at 2;2 ($M = 2{\cdot}72$, S.D. = 4·31) than at 1;6 ($M = 0{\cdot}81$, S.D. = 2·86). There was no effect of condition and no interaction. An inspection of mean production of words and gestures (see Table 2) reveals that infants age 1;6 produced the target symbol infrequently in either the verbal or gestural modality. In contrast, infants age 2;2 produced the targets in BOTH modalities. As is depicted in Table 2, this pattern in the older group was not

TABLE 2. *Mean number of target, 'other' and total utterances per child and number of children producing utterances from each category, broken down by condition and age* (n = *16/cell*)

	1;6			2;2		
Age	Target	Other	Total	Target	Other	Total
Word condition						
Frequency	1·44	8·06	9·50	2·25	59·00	61·25
# children	6	11	12	7	16	16
Gesture condition						
Frequency	0·19	9·31	9·88	3·19	7·44	10·63
# children	2	16	16	8	16	16

carried by a small number of infants producing each symbolic form many times. Instead, the targets were produced at least once by seven infants in the Word condition and eight infants in the Gesture condition. This analysis reveals no difference in infants' spontaneous production of verbal and gestural targets at either age, suggesting that at least some of the children in the Gesture condition were receptive to symbolic input in the gestural modality.

There were notable individual differences in children's production of the target gestures (range = 0–15). Interestingly, there were also gender differences in the frequency of target gesture production. Although the number of children in the Gesture condition producing target gestures did not differ reliably for males and females (five of eight females and three of eight males produced a target gesture at least once), girls who produced target gestures produced many more gestures ($M = 9{\cdot}0$) than did boys ($M = 1{\cdot}67$). This relation did not appear to be an artifact of sex differences in vocabulary size. Although the girls tended to have bigger productive vocabularies (as measured by the MacArthur CDI) than boys ($M = 402{\cdot}4$ and $341{\cdot}9$ for girls and boys respectively), there was no correlation between vocabulary size and target gesture production ($r(14) = -0{\cdot}01$). There are too few observations ($n = 8$ per gender) to draw generalizable conclusions regarding this trend, however, this finding is consistent with previous studies suggesting that girls may be more likely to employ symbolic gestures than boys (see, e.g. Acredolo & Goodwyn, 1988). In future work, it will be interesting to explore some of the potential contributors (such as differences in parental interaction styles) to gender differences in frequency of gestural communication.

Overall, however, the older children were equally likely to produce target words and target gestures. How can this apparent equivalence in production be reconciled with the evidence that these same children more readily mapped words than gestures to object categories in comprehension? To

answer this question, we examined the context in which the target words and gestures were produced. If the production data converges with the comprehension data, we should find that infants are more likely be referential in their production of verbal than gestural targets.

Referential versus non-referential target production. To assess whether target gestures were produced in as referential a manner as target words, we compared the proportion of target productions that were referential for words versus gestures. Because of the floor effect in the younger group, we performed separate analyses for each age group. As one might expect from the low incidence of target production in the children age 1;6, there was no effect of symbol type on percent referential target production at this age. However, at 2;2, there was an effect of symbol type such that children produced a significantly greater proportion of target words referentially than target gestures, $t(13) = 2{\cdot}19$, $p < 0{\cdot}05$ (See Figure 1). Thus, although these

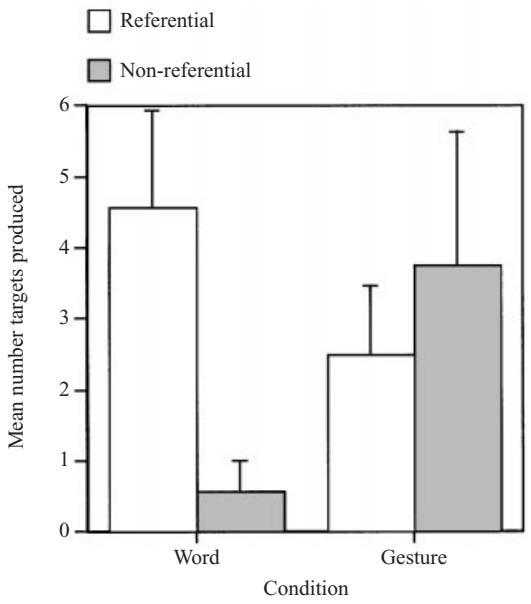

Fig. 1. Mean frequency of targets produced referentially and non-referentially at age 2;2 in the Word and Gesture conditions.

older infants were sufficiently interested in the target gestures to produce them, they only infrequently did so in a referential manner. More typically, the infants produced the target gestures as part of a social routine or an imitative game. For example, infants often imitated the experimenter

immediately after the experimenter produced the gesture, while gazing and smiling at the experimenter, but without apparent reference to the objects.

One alternative interpretation of these data is that children failed to demonstrate referential behavior when producing target gestures because the coding criteria were biased in favor of counting words as referential. Because we counted a target production as referential when it was produced while pointing to, gazing at, or holding up the target object, children in the Gesture condition would have had to perform two simultaneous gestures (e.g. a point and a target gesture) in all circumstances unless they were simply gazing at the object. To address this concern, we examined the proportion of referential productions that involved eye gaze only. As it turned out, the vast majority of referential productions in both the Word (95%) and Gesture (100%) condition involved eye gaze (although some included other referential acts as well, such as both pointing and gazing at the target object), suggesting that the inclusion of pointing and holding criterion did not systematically bias the classification system against the production of referential gestures.

Taken together with our findings from the comprehension data (Namy & Waxman, 1998), these data indicate that overall, infants age 1;6 employ words and gestures at comparable rates, but that by 2;2, words are emerging as the dominant symbolic form. Moreover, although infants age 2;2 produced both target words and target gestures, they have begun to employ them for different ends, using the target words in a primarily referential manner but typically producing the target gestures in a non-referential manner. To return to the original question of how production relates to comprehension, we find that a simple measure of frequency of production does not mirror the patterns of comprehension observed by Namy & Waxman (1998). Infants age 2;2, who more readily interpreted words than gestures as labels, produced target words and target gestures equally often. However, our analysis of how words and gestures are employed during production converges well with the developmental pattern observed in comprehension (Namy & Waxman, 1998) which suggests that words and gestures appear to be interpreted similarly at 1;6, but that by 2;2, infants' use of these two modalities has diverged.

The current data provide important insight into a question left unanswered in the comprehension data from these same infants (Namy & Waxman, 1998). Why did the older infants fail to interpret gestures as object names? One possible explanation is that infants noticed the novel gestures, but interpreted them in a fundamentally different way than they interpreted the novel words. But an alternative, less interesting possibility is that infants may have simply failed to notice the gestures produced by the experimenter. The production data presented here rule out this second, weaker alternative. The production of target gestures clearly indicates that they noticed the target

gestures. However, we found that at 2;2, infants did not employ the target gestures in a referential manner, in contrast to the manner in which they employed the target words.

Conclusions

These data provide evidence from a new source, the spontaneous production of novel words and gestures within an experimental session, regarding the developmental trend in infants' use of words and gestures as object names. The evidence from naturalistic production (Acredolo & Goodwyn, 1985, 1988; Goodwyn & Acredolo, 1993; Iverson *et al.*, 1994) experimental comprehension (Namy & Waxman, 1998; Namy, 2001) and experimental production (the present study) converges to suggest that at 1;6, infants accept both words and gestures as object names, but that infants age 2;2 show a strong preference for words over gestures. These findings highlight the changing role of gesture in the hearing infant's lexicon. Taken together, the combined findings from these various avenues of study imply that at 1;6, gestures appear to function as stand-alone symbols with the same representational potential as words. By 2;2, the function of gesture changes to an augmentative form of communication used to punctuate and amplify verbal communication rather than to name (see also McNeill, 1992). This analysis of spontaneous production in an experimental task provides strong evidence of a rising priority for the modality employed in the infants' native language, as they accrue greater knowledge and experience with language.

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