

PUBLISHED BY
 THE PRESS SYNDICATE OF THE UNIVERSITY OF CAMBRIDGE
 The Pitt Building, Trumpington Street, Cambridge CB2 1RP
 40 West 20th Street, New York, NY 10011-4211
 10 Stamford Road, Oakleigh, Victoria 3166, Australia

© Cambridge University Press 1992

Printed in Great Britain by the University Press, Cambridge

CONTENTS
 VOLUME 19

Articles	Page
ABBEDUTO, LEONARD, NUCCIO, JILL BIBLER, AL-MABUK, RADHI, ROTTO, PAMELA & MAAS, FAY. Interpreting and responding to spoken language: children's recognition and use of a speaker's goal	677
BASSANO, DOMINIQUE, HICKMANN, MAYA & CHAMPAUD, CHRISTIAN. Epistemic modality in French children's discourse: <i>to be sure</i> or <i>not to be sure</i> ?	389
BERG, THOMAS. Phonological harmony as a processing problem	225
BLAKE, JOANNA & DE BOYSSON-BARDIES, BÉNÉDICTE. Patterns in babbling: a cross-linguistic study	51
BRODERICK, VICTOR. Incidence of verbal comparisons in beginners' books and in metaphor comprehension research: a search for ecological validity	183
CHIN, STEVEN B. & DINNSEN, DANIEL A. Consonant clusters in disordered speech: constraints and correspondence patterns	259
DART, SARAH N. Narrative style in the two languages of a bilingual child	367
DOBRICH, WANDA & SCARBOROUGH, HOLLIS S. Phonological characteristics of words young children try to say	597
EDWARDS, JANE A. Computer methods in child language research: four principles for the use of archived data	435
FURROW, DAVID, MOORE, CHRIS, DAVIDGE, JANE & CHIASSON, LORRAINE. Mental terms in mothers' and children's speech: similarities and relationships	617
INGHAM, RICHARD. The optional subject phenomenon in young children's English: a case-study	133
JAEGER, JERI J. 'Not by the chair of my hinny hin hin': some general properties of slips of the tongue in young children	335
LANZA, ELIZABETH. Can bilingual two-year-olds code-switch?	633
LEVITT, ANDREA G. & AYDELOTT UTMAN, JENNIFER G. From babbling towards the sound systems of English and French: a longitudinal two-case study	19
LEVORATO, MARIA CHIARA & CACCIARI, CRISTINA. Children's comprehension and production of idioms: the role of context and familiarity	415
LIEVEN, ELENA V. M., PINE, JULIAN M. & BARNES, HELEN DRESNER. Individual differences in early vocabulary development: redefining the referential-expressive distinction	207

Comprehension and production of gesture in combination with speech in one-word speakers*

MAROLYN MORFORD AND SUSAN GOLDIN-MEADOW
The University of Chicago

(Received 10 July 1990. Revised 18 September 1991)

ABSTRACT

This study explores the role that gesture plays in the earliest stages of language learning. We describe how one-word speakers use gesture in combination with speech in their spontaneous communications, and interpret gesture presented in combination with speech in an experimental situation. Forty one-word speakers (ages 1;2.22 to 2;4.6) were videotaped in a free-play session which provided data on the child's spontaneous gesture and speech production. The children were also given a comprehension task in which the presence and absence of gesture were systematically varied in relation to speech. We found that (1) all of the children spontaneously produced gestures in combination with speech, and (2) all of the children were able to understand gesture when it was presented in combination with speech, not only when the gesture was redundant with speech but also when the gesture substituted for speech. These data suggest that, even at this young age, gesture naturally forms an integrated system with speech in both production and comprehension.

INTRODUCTION

What is the role of gesture, particularly when combined with speech, in the earliest stages of language development? Children have been reported to use gesture to communicate several months before they begin to speak at all

[*] This work was supported in part by a grant from the Smart Foundation. The authors thank the Department of Child Psychiatry at the University of Chicago and the Social Sciences Computer Laboratory at Elon College, North Carolina, for technical support provided for the research project, and Bennett Leventhal, Susan Levine, Marilyn Shatz and Jim Stigler for their particularly helpful comments on the project at various stages of its development. Addresses for correspondence: Marolyn Morford, 11704 Newbridge Court, Reston, VA 22091, USA; Susan Goldin-Meadow, University of Chicago, Department of Psychology, 5730 South Woodlawn Avenue, Chicago, IL 60637, USA.

(Bates, 1976). Even after they begin to produce single words, young children continue to use gesture not only by itself (that is, without speech) but also in combination with spoken words (Carter, 1975; Greenfield & Smith, 1976; Bates, Benigni, Bretherton, Camaioni & Volterra, 1979).

Two types of gesture-speech combinations predominate during the child's 'one-word' period of development: (1) gesture may be combined with speech to convey meaning redundant with the meaning of the spoken word, for example, pointing at an object and naming it (de Laguna, 1927; Guillaume, 1927; Leopold, 1949; Greenfield & Smith, 1976); or (2) gesture may be combined with speech to add a new semantic element to the meaning of the spoken word, such as an action (holding out a hand as though to receive an object and saying *juice*) or a possession (pointing at mother's comb and saying *mommy*) (Greenfield & Smith, 1976; see also Masur, 1982, 1983; Goldin-Meadow & Morford, 1985; Zinober & Martlew, 1985; Boswell, 1988).

While it has been noted that children at the one-word stage frequently produce gestures both alone and in combination with single words, the potential role of these gestures in language acquisition has been downplayed. This omission may reflect the fact that, even though gesture occurs frequently in adult communications with children (Murphy & Messer, 1977; Chapman, 1981), those adult gestures are not patterned in any consistent way with the grammatical structures of language (Shatz, 1982; Schaffer, Hepburn & Collis, 1983; Schnur & Shatz, 1984); that is, there is no consistent mapping between the types of gesture adults produce to children and the structure of the sentences those gestures accompany. This consistent mapping, Shatz (1982) has argued, must be present in order for children to be able to use gesture to discover the grammatical structures present in the language they hear.

Even though gesture may not serve as an easily accessible route into the grammar of language, it might assist the child in deriving meaning from an adult's spoken utterance. For example, in a study of directives spontaneously produced by mothers to children aged 0;10 and 1;6, Schaffer *et al.* (1983) found that gesture often provided information that could help the child interpret the mother's directive; e.g. the mother pointed at the teddy while saying, 'put the hat on teddy,' thus using gesture to focus the child's attention on the location for the desired action. A gesture of this sort can be of use to young children only if they are able to interpret that gesture, and they are able to integrate the information they receive from gesture with the information they receive from speech.

Much of the research on children's ability to comprehend gesture has focused on their responses to the pointing gesture. Studies have shown that young children, often even before they themselves produce pointing gestures to orient another's attention toward an object, respond to pointing gestures

by directing their attention to the object indicated by the point (Lempers, Flavell & Flavell, 1976; Murphy & Messer, 1977; Leung & Rheingold, 1981). These studies provide evidence that young children can interpret the pointing gesture and that they tend to interpret this gesture as a reference to an object. However, since none of the studies systematically varied the speech produced along with the pointing gesture, they do not provide evidence as to whether young children can integrate the information conveyed in gesture with the information conveyed in speech.

Two studies have explicitly explored the role that gesture plays in a young child's comprehension of speech. Allen & Shatz (1983) presented children aged 1;4 to 1;6 with a series of *what*-questions while varying whether the question was presented alone or with a gesture – either a hold-up gesture that indicated an object relevant to the question ('what says meow?' + hold-up a toy cat) or a hold-up gesture that indicated an object irrelevant to the question ('what says meow?' + hold-up a toy cow). Allen & Shatz found that the children were more likely to provide some sort of response when the spoken question was accompanied by a gesture but that the proportion of correct verbal responses was not enhanced. From these data, they concluded that gestural information is processed relatively independently of speech, at this stage of development, and that gesture serves as little more than an attention-getter and as a general prompt to action. We can speculate, however, that the particular gesture Allen & Shatz used in their study – the hold-up gesture – might not be expected to do much more than focus attention on an object and perhaps offer that object for the taking.

Macnamara (1977) conducted a series of studies in which he presented children aged 1;2 to 1;8 with two types of gestures – the hold-out gesture, in which an object is extended toward the child as though offering it, and the pointing gesture – and varied the speech that accompanied each gesture. The children were found to respond differentially to the two gestures. In response to a hold-out, they took the object; in response to a point, they either looked at the object or did nothing. Moreover, when there was conflict between the information conveyed in gesture and in speech (for example, if the object mentioned in speech was not the same object which was held out), or if the speech was uninterpretable (as when the object was named in an unknown language, French), the gesture took precedence and the child took (or looked at) the object referred to by the gesture.

It is important to note that neither the Allen & Shatz (1983) study nor the Macnamara (1977) study included a condition in which the child was required to understand gesture in order to respond correctly to the utterance. In both studies, the gesture provided information that was either redundant or in conflict with the information provided in speech. Thus, these studies provide incomplete insight into whether young children are able to integrate information across gestural and verbal modalities.

The goal of the current study is to explore gesture comprehension, as well as gesture production, in young language-learners, focusing particularly on the child's ability to integrate information across gesture and speech. For a population of children at the one-word stage, we first describe the spectrum of spontaneous gesture production, by establishing a taxonomy of how one-word speakers use gesture alone and in combination with speech in their spontaneous communications. We then assess gesture comprehension: in an experimental setting, we evaluate how these same one-word speakers interpret gesture when presented either alone or in combination with speech. The study is designed to assess the children's understanding of gesture, (1) when it is combined with speech to convey meaning redundant with the meaning of the spoken word; and (2) when it is combined with speech to add a new semantic element to the meaning of the spoken word. With these observations, we hope to establish both the productive and receptive aspects of the role of gesture in the earliest stages of language learning, and emphasize the importance of considering gesture in the study of language development.

METHOD

Subjects

Subjects were obtained through an advertisement placed in a university newspaper in central North Carolina. Children were considered potential subjects only if they were producing one-word speech and had not yet advanced to word combinations (three children were eliminated from the study because they produced two-word combinations during the initial screening session).

The children were visited in their homes two or three times. Based on observations of their gesture-speech production during the first visit, the children were categorized into two groups: Group 1 children produced only those combinations of gesture and speech in which gesture and speech conveyed essentially redundant information (e.g. point at man + *man*, or open palm extended with the palm up as though to receive an object + *give*). Group 2 children produced at least one gesture-speech combination in which gesture and speech conveyed different, supplemental information which, taken together, formed an interpretable two-element 'phrase' (e.g. point at man + *big*, or extended palm-up reach + *juice*). The first 20 children observed who met the criterion for Group 1 were classified as such, as were the first 20 children who met the criterion for Group 2. A total of 46 children (all but one of whom gestured and produced some gesture-speech combinations) were observed in order to obtain the 40 children who comprised the subject population for this study. These 40 children ranged in age from 1;2.22 to 2;4.6.

Spontaneous gesture production

During the first visit to the child's home, the parent was told that the nature of the study was to examine all aspects of children's early communication abilities. No other details of the study were provided. The child was videotaped in a free-play situation with the parent (generally the mother) for 15 minutes during which the mother was asked to play normally with her child and to encourage the child to communicate with her (to label toys, to ask questions, etc.). This videotaped sequence and observations during the interview provided the data on the child's gesture and speech production.

Gesture comprehension task

At the second and third home visits, a five-part gesture comprehension task was administered. It comprised three combination conditions and two single-item conditions. The purpose of the single-item conditions was to determine the children's responses to individual gesture and speech forms in order to serve as a baseline against which to evaluate the children's responses to the combination forms. The two single-item conditions were:

- (1) SINGLE-WORD CONDITION, e.g. 'give'.
- (2) SINGLE-GESTURE CONDITION, e.g. GIVE gesture (hand extended palm-up).

The three combination conditions varied gesture and word combinations to assess the influence, if any, of gesture on children's speech comprehension. Each item was designed to convey the same meaning in all three combination conditions. The three conditions were:

- (3) NO GESTURE CONDITION (a spoken multi-word combination, containing two content words and a function word, was presented to the child without any gesture), e.g. 'give the clock'.
- (4) REDUNDANT GESTURE CONDITION (a spoken multi-word combination, containing two content words and a function word, was presented along with a gesture that was redundant with one of the content words in the combination), e.g. 'give the clock' + GIVE.
- (5) replacement gesture condition (a SINGLE spoken word was presented along with a gesture that replaced the omitted content word in the combination), e.g. 'clock' + GIVE.

Performance on the No Gesture condition provided a baseline level of comprehension against which the Redundant Gesture and Replacement Gesture conditions could be compared. A comparison of the Redundant Gesture vs. the No Gesture combinations addressed the question: can Redundant Gesture improve speech comprehension in one-word speakers?

A comparison of the Replacement Gesture vs. the No Gesture combinations addressed the question: can children integrate the information conveyed in gesture and speech, and interpret a gesture in combination with a word as well as a word in combination with a word?

Four different types of gesture were included in the comprehension task: six POINT gestures, four GIVE gestures (hand extended to child, palm-up), one THROW gesture, and one SHAKE gesture (both performed as if an object were in the hand). The 12 nouns and 5 verbs used in the comprehension task were drawn from known vocabularies of children in the one-word stage (cf. Nelson, 1973; Huttenlocher, 1974; Goldin-Meadow, Seligman & Gelman, 1976). There were 12 items in each of the five conditions; thus each child received 60 items in all. All items were requests and so required a response from the child. The complete comprehension task is presented in Table 1.

All items across all conditions were presented randomly to each child. Randomization was achieved by shuffling the 60 index cards upon which each individual item was listed before beginning the comprehension test with each child. Three identical decks of cards were constructed so that if a child did not complete the entire task in one sitting, that child's deck was banded and put aside for the next visit. Given the young age of the subjects, the length of the comprehension task, and the desire to maintain a fairly normal 'play' interaction, it was not always possible to control the exact number of objects present when an item on the comprehension test was presented to the child. However, the experimenter did ensure that, for every item, at least three toys were present in front of the child. This stipulation allowed for a greater than chance response to any item presented, and also permitted a response when no object was indicated in the stimulus (e.g. 'give' in the Single-Word condition, or GIVE gesture in the Single-Gesture condition).

Descriptive measures

On the initial visit, the parents were asked questions about their educational level, the number of hours the child spent in daycare, and the age at which the child learned to walk. On the final visit, the Peabody Picture Vocabulary Test-Revised (Form M) and the Bayley Scales were administered to assess developmental level.

Coding

Spontaneous production. Recognizable words were transcribed as heard from the free-play videotapes. The words were categorized simply, according to part of speech: noun, verb (including particles such as *up*, *down*, etc.), adjectives, and modulating words such as *yes*, *no*, *uh-huh*, *hi*, *bye*, etc. Babbling, 'protowords', or sounds interpreted as meaningful by the mother but uninterpretable by the coders were not transcribed.

TABLE 1. *Gesture comprehension task*^a

Combination conditions	Single-item conditions	
	Single word	Single gesture
No Gesture		
Redundant Gesture		
Replacement Gesture		
'Give the bottle'	'Give' + POINT at bottle	POINT at bottle
'Give the shoe'	'Give' + POINT at shoe	POINT at shoe
'Open the bag'	'Open' + POINT at bag	POINT at bag
'Open the box'	'Open' + POINT at box	POINT at box
'Push the ball'	'Push' + POINT at ball	POINT at ball
'Push the dog'	'Push' + POINT at dog	POINT at dog
'Give the cookie'	'Cookie' + GIVE	GIVE
'Give the clock'	'Clock' + GIVE	GIVE
'Give the car'	'Car' + GIVE	GIVE
'Give the baby'	'Baby' + GIVE	GIVE
'Throw the cat'	'Cat' + THROW	THROW
'Shake the book'	'Book' + SHAKE	SHAKE

^a Each child received 12 items in each of five conditions (a total of 60 items, all requests). The items in capital letters on the table represent gestures.

All communicative manual and head movements were described from the tapes. It was noted whether the gesture occurred alone, in combination with another gesture, or in combination with a word. Gesture and word combinations were categorized into those in which gesture conveyed information redundant with the speech and those in which gesture conveyed information that was different from the speech.

Inter-rater reliability was obtained by having two coders independently transcribe the videotapes of the free-play sessions of a subset of the children. Inter-rater agreement for speech and gesture was 97%. Comparisons between groups were performed on the production data using Student's *t*-test for unpaired samples.

Comprehension. The children's responses to the comprehension task were coded immediately after each item was presented. Their actual behaviours were described on-site and later placed into categories depending upon the appropriateness of the response to the stimulus. For the combination conditions (No Gesture, Redundant Gesture, and Replacement Gesture), there were two units of meaning for each item: an action the children were requested to carry out, and the object on which they were to act. The children were required to respond to each combination with the correct action on the correct object in order to be counted as having understood and therefore having responded correctly to that item (see Boswell, 1988, for a complete description of the behaviours recorded and the coding categories).

In contrast, for the single-item conditions, only one unit of meaning was conveyed in the stimulus (the object in items 1-6; the action in items 7-12; see Table 1), and the child was required to respond with that unit (independent of whatever else he or she did on that item) in order to be considered correct on the item. For the single items denoting objects (that is, the noun items in the Single-Word condition, and the POINT items in the Single-Gesture condition), the experimenter recorded whether the child indicated the correct object in response to the stimulus. In addition, if the child performed an action on the correct object, that action was recorded; however, it is important to note that the child was considered correct no matter what action he or she performed on that object, or if he or she performed no action and merely looked at (or for the Single-Gesture condition, labelled) the object. For the single items denoting actions (that is, 'give', 'shake' and 'throw' in the Single-Word condition and the corresponding gestures in the Single-Gesture condition), the experimenter recorded whether the child performed the correct action in response to the stimulus. In addition, the object on which the child had performed the correct action was recorded; again, for these items the child was considered correct no matter what object he or she performed that action on.

In all conditions, the experimenter was careful to produce the GIVE gesture (which, in naturalistic discourse, is often directed toward the desired object) in the direction of the child and not the object so that (as in the other two action gestures) the child would receive no information from the gesture itself about which object was to be acted upon. Thus, in the Replacement-Gesture condition, in order to determine the correct object to give, the child had to be able to understand the noun that accompanied the GIVE gesture and to integrate that information with the information conveyed in gesture.

Inter-rater reliability was obtained by having a second observer code five randomly selected comprehension tasks that had been videotaped. Inter-rater agreement on responses to combinations and single items was 94%.

Test-retest reliability for the comprehension task was obtained by re-administering the task to 15 of the 40 children one to two weeks after the

first administration, using an alternate word list to avoid practice effects. The correlation for the two time periods was 0.71, significant at the 0.05 level (13 d.f.).

Comparisons between groups and across conditions were made on the comprehension data using analysis of variance with repeated measures; pairwise comparisons were subsequently performed using the Newman-Keuls test.

RESULTS

Descriptive measures

Table 2 presents means for the children in Group 1 and Group 2 for age, birth order, Peabody Picture Vocabulary Test-Revised score, Bayley Mental IQ, Bayley Motor IQ, number of hours spent per week in daycare, parent education, and age at which the child began to walk. There were no significant differences between the two groups in any of these measures.

Spontaneous production

Single items. Table 3 presents the mean number of single words, single gestures, and combinations produced by children in the two groups during the 15 minute play period.¹ As the table indicates, both groups of children produced single word utterances, but Group 2 produced them significantly more often than Group 1 ($t(33) = 1.73, p = 0.046$). For both groups, the predominant type of single word produced was the noun (79% of the total number of single words produced for Group 1, 69% for Group 2). Verbs and adjectives accounted for only 5% of single-word production for Group 1 and 9% for Group 2. The remaining words were 'modulating' words such as *yes*, *no*, *uh-oh*, *uh-huh*, etc. (16% for Group 1, 22% for Group 2).

In addition, both groups of children produced single gestures, although less often than either group produced single words. There was no significant difference between the two groups in the number of single gestures produced. Both groups used their single gestures predominantly to indicate objects, either by pointing at the object (70% of the total number of single gestures produced for Group 1, 55% for Group 2) or by holding up the object to display it (18% for Group 1, 20% for Group 2). The only action gesture produced by either group was the GIVE gesture (hand extended palm-up) and it accounted for only 5% of the single gesture production for Group 1 and 9% for Group 2. The remaining gestures were head nods, shakes, hand waves, etc. (6% for Group 1, 17% for Group 2).

[1] Due to experimenter error or equipment failure during certain of the free-play sessions, data were available for speech and gesture coding for only 17 of the 20 children in Group 1, and 18 of the 20 children in Group 2.

TABLE 2. *Characteristics of subjects*

	Group 1 (N = 20)		Group 2 (N = 20)	
	Mean	(s.d.)	Mean	(s.d.)
Age	1;6.24	(0;3.6)	1;8.15	(0;3.6)
Birth order	1.75	(0.8)	1.4	(0.5)
PPVT score	8.1	(3.4)	7.9	(3.8)
Bayley Mental IQ	131.6	(18.3)	125.8	(17.1)
Bayley Motor IQ	119.9	(16.7)	114.9	(12.9)
Hr/Wk daycare	5.2	(9.9)	11.7	(15.1)
Mother education (yr)	16.8	(1.9)	16.6	(1.6)
Father education (yr)	18.3	(2.7)	18.25	(1.9)
Age walk	1;0.6	0;1.9	0;11.18	0;1.24

TABLE 3. *Spontaneous production of words and gestures
(mean per 15 minutes recorded time)*

	Group 1 (N = 17)		Group 2 (N = 18)	
	Mean	(s.d.)	Mean	(s.d.)
Single items				
Single words	25.02	(18.9)	37.66	(23.7)*
Single gestures	13.70	(8.1)	10.55	(9.6)
Combinations				
Gesture + gesture	0.00		0.22	(0.54)
Gesture + word				
(1) Gesture provides information redundant with the word	10.55	(9.5)	6.81	(3.9)
(2) Gesture provides information different from the word	—		4.17	(3.2)
Word + word	—		—	

* $p < 0.05$.

Combinations. As Table 3 indicates, only children in Group 2 produced gesture-gesture combinations, e.g. a child rocked his own body and held up a toy horse to comment on a toy rocking horse. This type of combination was extremely infrequent: three children produced a total of four such combinations.

Groups 1 and 2 produced approximately the same mean number of gesture-speech combinations (10.55 for Group 1, 10.98 for Group 2). By definition, all of Group 1's gesture-speech combinations contained gesture which conveyed information redundant with the information conveyed in

speech. In contrast, only 62% of Group 2's gesture-speech combinations were of this type; the remaining 38% contained gesture which conveyed different information from that conveyed in speech.

For both groups, the predominant gesture-speech combination in which gesture was redundant with speech contained a pointing (or hold-up) gesture indicating an object, combined with a noun indicating the same object, e.g. POINT at bottle + *bottle* (98% for Group 1, 88% for Group 2). In addition, Group 2 produced a small percentage (2%) of action gestures (all of which were the GIVE gesture) combined with the verb *give*. The remaining combinations of this type were head movements combined with a matching word, e.g. nod + *yes* (3% for Group 1, 10% for Group 2).

The children in Group 2 produced four kinds of gesture-speech combination in which gesture conveyed different information from speech: (1) a pointing (or hold-up) gesture combined with a verb or adjective, e.g. POINT at man + *riding* (43% of these gesture-speech combinations were of this type); (2) a pointing (or hold-up) gesture indicating one object combined with a noun indicating a different object, e.g. HOLD-UP boat + *water* (25%); (3) an action gesture (all but one were GIVE gestures) combined with a noun, e.g. GIVE + *bottle* (20%); and (4) a head movement combined with a noun, e.g. nod + *Bert* (12%).

As indicated above, children were included in the study only if they produced single words. Thus, neither group of children produced two-word combinations.

Comprehension

Comprehension of combinations with and without gesture. The children in Groups 1 and 2 were selected to differ in their spontaneous PRODUCTION of gesture-speech combinations: Group 1 produced only those combinations in which gesture was redundant with speech, while Group 2 produced combinations in which gesture added information to speech (as well as those in which it was redundant). The comprehension task tested the hypothesis that the two groups of children differed in their ability to decode these two different types of gesture-speech combinations.

Fig. 1 presents the mean number of correct responses produced by Groups 1 and 2 in response to each of the three combination conditions: No Gesture, Redundant Gesture, and Replacement Gesture. Although Group 2's mean performance was somewhat higher than Group 1's, the difference was not significant ($F(1, 38) = 2.542$, $p = 0.12$). Moreover, the pattern of responses across the three conditions was the same for both groups (i.e. there was no significant interaction between group and condition, $F(2, 76) = 0.135$, $p = 0.87$.)

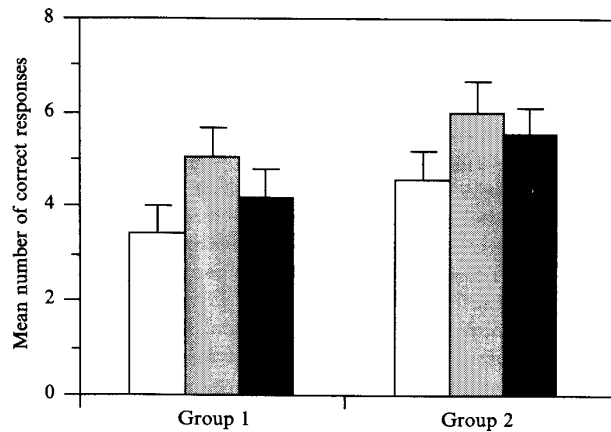


Fig. 1. Mean number of correct responses on the three combination conditions of the comprehension test. (The horizontal lines over the bars represent standard error of the means.) □, No Gesture; ▨, Redundant Gesture; ■, Replacement Gesture.

The children taken as a whole, however, did differ significantly in their performance on the three types of combination ($F(2, 76) = 9.92, p = 0.001$). Performance was higher on Redundant Gesture combinations than on No Gesture combinations ($p < 0.01$, Newman-Keuls), suggesting that a redundant gesture can improve a child's comprehension of a two-word spoken sequence. In addition, and more surprisingly, performance was higher on Replacement Gesture combinations than on No Gesture combinations ($p < 0.05$, Newman-Keuls). This finding suggests that one-word speakers can interpret gesture in combination with a word better than they can interpret a word in combination with a word. There was no significant difference comparing performance on Redundant Gesture combinations vs. Replacement Gesture combinations.

It is important to note that, in both the No Gesture and Replacement Gesture conditions, the children seemed to glean information from each of the two elements in the combination, rather than arriving at the meaning of the combination on the basis of only one of the two elements. For example, the children were more likely to respond correctly, that is, to push the dog,

[2] Since the children in both Group 1 and Group 2 covered a wide age range, it was possible that, independent of Group, younger children might perform differently from older children on the combinations in the gesture comprehension task. To explore this possibility, we divided the children into two groups based on the median age of the 40 children: 25 children below the median (1;2.22 to 1;5.31) and 15 children above the median (1;6 to 2;4.6). We found that the younger children performed no differently on the combinations in the gesture comprehension test than the older children ($F(1, 38) = 0.208, p = 0.651$).

when given the combination 'push the dog' or the combination 'push' + POINT at dog, than when given the single word 'dog' or the single gesture POINT at dog. In general, the mean number of correct object + action responses given to a two-word combination (4.1) or to a word + gesture combination (4.9) was much higher than the mean number of those same object + action responses given to the single words (0.7) or the single gestures (1.0) that comprised those combinations.³ This result was found for both Group 1 (3.5 and 4.3 for the combinations vs. 0.7 and 1.0 for the single items) and Group 2 (4.7 and 5.6 for the combinations vs. 0.8 and 1.0 for the single items). Moreover, the pattern was found for each of the five verbs in the No Gesture condition ('give', 'open', 'push', 'throw', and 'shake'); that is, the number of correct object + action responses was greater for each of the five different types of two-word combination than for their respective single-word items (e.g. 'push the dog' vs. 'dog'; 'throw the cat' vs. 'throw'). Similarly, the pattern was found for each of the four gestures in the Replacement Gesture condition (POINT, GIVE, THROW, and SHAKE); that is, the number of correct object + action responses was greater for each of the four different types of word + gesture combination than for their respective single-gesture items (e.g. 'give' + POINT at bottle vs. 'bottle' or POINT at bottle; 'book' + SHAKE vs. 'shake' or SHAKE).

Comprehension of different types of gesture. Fig. 2 presents the mean proportion of correct responses for each of the three combination conditions categorized according to the type of gesture in each combination: POINT gestures, GIVE gestures, and THROW/SHAKE gestures (note that, for the no gesture condition, the proportions are for those two-word combinations which convey the same meanings as the combinations containing the three different types of gesture; data from the THROW gesture and the SHAKE gesture were combined since there was only one item of each type in each condition). No difference was found comparing Groups 1 and 2 in this analysis ($F(1, 38) = 2.247, p = 0.142$); consequently, the data for the two groups have been combined. Performance differed across the three combination conditions ($F(2, 78) = 5.32, p = 0.007$) and across the three types of gesture ($F(2, 78) = 10.3, p = 0.0001$).

Moreover, performance differed for the three gestures depending upon the combination in which they occurred (i.e. there was an interaction between type of gesture and type of combination, $F(4, 156) = 3.28, p = 0.013$). It is

[3] Most of the correct object + action responses given to single words or single gestures were produced on item 3 ('open the bag') and item 4 ('open the box') simply because the action the children were most likely to perform on the bag or the box was opening. Nevertheless, as described in the text, even for these two items, the children still produced more correct action + object responses on the two-word combinations and on the word + gesture combinations than on the single words or single gestures.

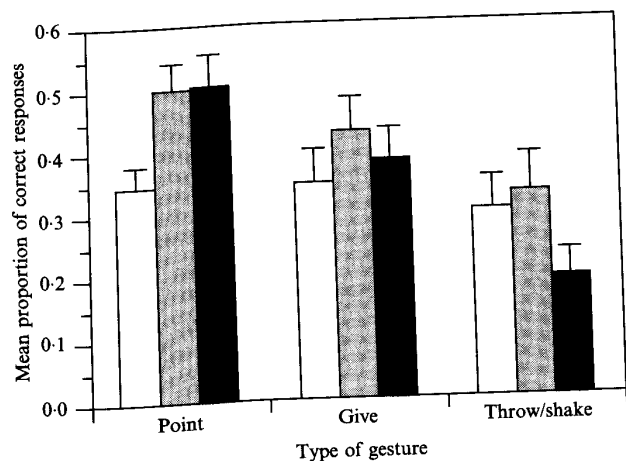


Fig. 2. Mean proportion of correct responses on the three combination conditions of the comprehension test categorized according to type of gesture. (For the no gesture condition, the proportions are for those two-word combinations which convey the same meanings as the corresponding combinations containing the three different types of gesture. The horizontal lines over the bars represent standard error.) □, No Gesture; ▨, Redundant Gesture; ■, Replacement Gesture.

worth noting, first, that the children produced the same proportion of correct responses on the two-word combinations corresponding to the three types of gestures, when there was no gesture presented along with the words, i.e. in the No Gesture condition ($F(2, 78) = 0.472$, $p = 0.626$). Thus, the words in the No Gesture combinations seemed to be understood equally well, suggesting that any differences found in the redundant and Replacement Gesture conditions can be attributed to the presence of the gesture.

There were, in fact, reliable differences across the types of gesture in both the Redundant Gesture condition ($F(2, 78) = 4.178$, $p = 0.019$) and the Replacement Gesture condition ($F(2, 78) = 13.123$, $p < 0.0001$). The children understood a two-word sentence containing a Redundant Gesture better than the same sentence without the gesture, but only if the gesture was a POINT (i.e. performance on Redundant Gesture combinations was better than on No Gesture combinations for the POINT gesture, $p < 0.05$, Newman-Keuls, but not for the GIVE or THROW/SHAKE gestures). However, while a redundant GIVE gesture or THROW/SHAKE gesture did not improve performance on a two-word sentence, neither gesture interfered with comprehension of the sentence.

In addition, the children were able to understand a combination containing a word and either a POINT gesture or a GIVE gesture better than, or at least

as well as, a two-word combination conveying the same meaning (i.e. performance on Replacement Gesture combinations was better than on No Gesture combinations for the POINT gesture, $p < 0.05$, Newman-Keuls, and not different for the GIVE gesture). In contrast, the children did not appear to understand combinations containing a noun and the THROW/SHAKE gesture (i.e. there were FEWER correct responses on Replacement Gesture combinations than on No Gesture combinations for the THROW/SHAKE gesture, $p < 0.05$, Newman-Keuls).

The different patterns of responses for the three types of gesture seen in Fig. 2 suggest that these three gestures were not equally comprehensible to the children. To investigate this possibility, we examined the children's performance on each of the three gesture types in the single gesture condition. Fig. 3 presents the mean proportion of correct responses on the

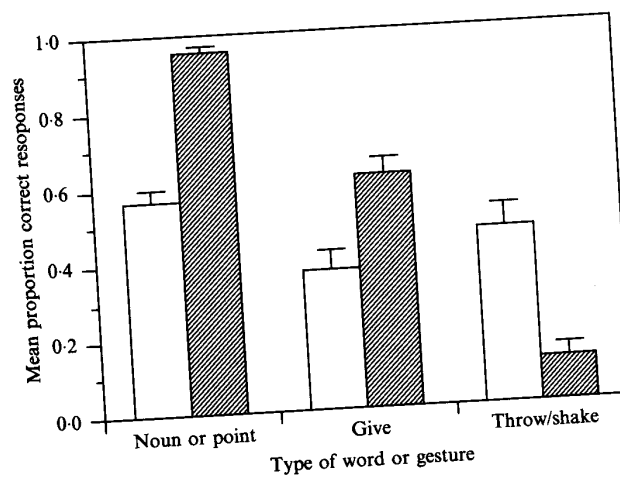


Fig. 3. Mean proportion of correct responses on the two single-item conditions of the comprehension test categorized according to type of word or gesture. (The horizontal lines over the bars represent standard error of the means.) □, Single Word; ▨, Single Gesture.

Single-Gesture condition and, for comparison, the Single-Word condition, categorized according to type of stimulus presented. Indeed, the children differed in the mean proportion of correct responses they gave to the three types of stimulus ($F(2, 78) = 70.64$, $p < 0.001$), and there was an interaction between the types of stimulus and whether it was presented as a word or a gesture ($F(2, 78) = 50.34$, $p < 0.001$). While the children gave proportionately MORE correct responses to the POINT gesture and the GIVE gesture than to the corresponding words (0.95 vs. 0.57 for the POINT, 0.61 vs. 0.37

for the GIVE; $p < 0.01$ for both comparisons, Newman-Keuls), they gave FEWER correct responses to the THROW and SHAKE gestures than to the corresponding words (0.11 vs. 0.46; $p < 0.01$, Newman-Keuls). This pattern was found for the children in both groups; that is, the children in Group 1 and Group 2 did not differ in the mean proportion of correct responses they gave to the three different types of stimulus in the Single-Gesture or Single-Word conditions ($F(2, 76) = 0.287$, $p = 0.752$).

Thus, the children appeared to understand the POINT gesture quite well and the GIVE gesture moderately well. This pattern may well explain why a POINT at an object could actually facilitate comprehension of the two-word combinations containing a noun for that object in the Redundant Gesture condition, and why both POINT and GIVE gestures could substitute for the corresponding words in the word+gesture combinations in the replacement gesture condition (see Fig. 2). It is also worth noting, that even though the POINT gesture was better understood than the GIVE gesture when presented alone, the two gestures seemed to be able to substitute for one another with little effect on comprehension in certain combinations. For example, the children gave the same proportion of correct responses when the request was 'give'+POINT at bottle (0.39 on items 1-2 in the Replacement Gesture condition) as when it was GIVE+'cookie' (0.38 on items 7-10 in the Replacement Gesture condition). Moreover, the two gestures seemed to be equally effective in facilitating comprehension when paired as redundant gestures with a sentence containing 'give'. The children gave the same proportion of correct responses when the request was 'give the bottle'+POINT at bottle (0.44 on items 1-2 in the Redundant Gesture condition vs. 0.33 on these items in the No Gesture condition) as when it was 'give the cookie'+GIVE (0.44 on items 7-10 in the Redundant Gesture condition vs. 0.34 on these items in the No Gesture condition).

In contrast to their relatively good understanding of the POINT and GIVE gestures, the children appeared to have a limited understanding of the THROW and SHAKE gestures. Thus, it is not surprising that these gestures did not facilitate comprehension of two-word sentences containing the words 'throw' or 'shake', nor is it surprising that the THROW and SHAKE gestures failed to serve as comprehensible replacements for the words 'throw' or 'shake' in a word+gesture combination (see Fig. 2).

The relationship between spontaneous production and comprehension

All 40 of the children in the study were found to produce POINT gestures spontaneously, either alone or in combination with words. Moreover, all but two of the children produced correct responses on at least 5 of the 6 POINT items in the single gesture condition of the comprehension test. Thus, essentially all of the children in the study both understood and produced the POINT gesture.

In contrast, none of the 40 children spontaneously produced either a THROW or a SHAKE gesture. Moreover, only eight of the 40 children produced any correct responses on the THROW and SHAKE items in the Single-Gesture condition of the comprehension test. Thus, almost none of the children in the study understood and produced the two iconic gestures, a result which may not be surprising given how infrequently young children in general produce iconic gestures (cf. Goldin-Meadow & Morford, 1985) and given how much difficulty they typically have in understanding gestures of this sort (cf. Petitto, 1988).

The GIVE gesture was the only gesture on which there was variability across the children: 11 children spontaneously produced a GIVE gesture, and 22 children (including 5 of the 11 GIVE producers)⁴ gave correct responses on at least 3 of the 4 GIVE items in the Single-Gesture condition of the comprehension test. Thus, approximately one-quarter of the children in the study produced the GIVE gesture, and approximately half understood the gesture. Because there was sufficient variability in the children's knowledge of the GIVE gesture, we explored whether children who had control of this gesture performed better on the comprehension test than children who did not. We first examined the GIVE producers and found that the 11 children who spontaneously produced GIVE (4 of whom were in Group 1 and 7 in Group 2) performed no better on the combination conditions of the comprehension test than the 29 children who did not produce GIVE (4.8 mean items correct vs. 5.0, $F(1, 38) = 0.065$, $p = 0.80$). However, we found that the 22 children who understood GIVE (12 of whom were in Group 1 and 10 of whom were in Group 2) did perform significantly better on the combination conditions of the comprehension test than the 18 children who did not understand GIVE (6.0 mean items correct vs. 3.5, $F(1, 38) = 14.672$, $p = 0.0005$). Perhaps most importantly, both groups of children showed a significant effect of type of combination; that is, performance was better on the Redundant Gesture and the Replacement Gesture conditions than on the No Gesture condition for those who understood GIVE, as well as for those who did not understand GIVE ($F(2, 76) = 9.494$, $p = 0.0002$). Thus, at whatever level of gesture comprehension children found themselves, they seemed to be able to take the information gleaned from the gesture and integrate it with the information from speech.

In sum, the data from this study suggest that, as long as a child understands a particular gesture, that gesture can augment the child's comprehension of a two-word sentence when the gesture is redundant with one of the words. Moreover, the gesture can actually serve as a substantive

[4] Nine of the 11 GIVE producers produced at least one correct response on the GIVE items in the Single-Gesture condition of the comprehension test; thus, only two of the producers failed to show any comprehension of the GIVE gesture.

replacement for one of the words in the sentence, permitting comprehension which is as good as (or better than) comprehension of the word combined with another word.

DISCUSSION

The role of gesture in children's attempts to communicate

The children in this study, all one-word speakers, used gesture rather frequently, particularly relative to the amount of speech they produced. On average, the children produced 1.5 gestures per minute (alone or in combination with speech), compared to 2.8 words per minute (alone or in combination with gesture). This rate of gesture production is quite comparable to the rate of gesture production by adults. For example, Bekken (1989) found that, on average, mothers produced 1.1 gestures per minute when conversing with their daughters aged 1;6 and 1;6 gestures per minute when conversing with other adults.

The children in this study did, however, differ from previously described adults in that a large percentage of their gestures were produced without speech (24% of their communications were gesture alone), while none of Bekken's (1989) adults produced gesture without speech. It is worth noting that this amount of gesture without speech appears to be typical for children at the beginning stages of language-learning. In a longitudinal study of three children ranging in age from 0;10 to 2;6, Goldin-Meadow & Morford (1985) found that 17%, 24%, and 34% of each child's communications contained gesture without speech. Thus, gesture appears to assume more of the burden of communication for a child at the earliest stages of language-learning than for an adult fluent in speech.

The children in this study also differed from adults in variety of gestures. The children produced essentially three types of gesture: the POINT gesture, the HOLD-UP gesture, and the GIVE gesture (hand extended, palm-up). In contrast, adults (and older children) typically produce a large range of iconic and metaphoric gestures, in addition to their pointing gestures (cf. McNeill, 1987). Nevertheless, the children in this study did use their limited repertoire of gestures to complement speech in the same ways that adults and older children do; in particular, they produced gesture-speech combinations in which gesture conveys the same information as speech, as well as gesture-speech combinations in which gesture conveys different information from speech (cf. Kendon, 1972, 1980; Church & Goldin-Meadow, 1986; McNeill, 1987, 1991; Perry, Church & Goldin-Meadow, 1988).

The role of gesture in children's comprehension of speech

The children in this study responded in specific ways to the gestures in the comprehension task. They looked at or touched the object indicated in response to a POINT gesture, offered an object in response to a GIVE gesture, and generally did not act at all in response to a THROW or SHAKE gesture. Thus, the gestures used in this study did not function merely to arouse the child's attention (as has been suggested in the literature, cf. Chapman, 1981; Allen & Shatz, 1983; Schnur & Shatz, 1984) but elicited responses specific to the type of gesture presented.

Moreover, the results of this study show that, if a gesture is comprehensible to children, they can interpret that gesture along with the speech they hear and integrate the information conveyed by gesture into the information conveyed by speech. If the gesture provides information which is redundant with the speech it accompanies, that gesture tends to augment a child's understanding of the speech. If the gesture provides information which is different from (but not contradictory to) the speech it accompanies, that information can be integrated with the speech, essentially allowing the gesture to serve as a substitute for a word.

The ability to integrate gesture and speech, which children appear to develop very early, is evident in adults as well. For example, Goldin-Meadow, Wein and Chang (in press) have shown that teachers are sensitive to the information conveyed in gesture and its relationship to speech in a child's explanations of a task, and tend to base their assessments of the child's understanding of the task on this gesture-speech information. Thus, gesture can provide insight into the mind of a speaker for both the adult and the young child.

Why might gesture and speech form such an integrated system? McNeill (1985, 1987) has suggested that gestures are manual symbols which emerge from the same psychological base or cognitive representation ('computational stage' is his term) as speech. This cognitive representation comprises a coordinated image and an inner speech symbol. A transformation on this dual representation takes place to produce a gesture form; a related, more complex transformation occurs on this same representation to produce a speech form. Thus, McNeill posits that gesture and speech are derived from the same source, a hypothesis which can account for the fact that many of the combinations produced by both groups of children in this study contained gestures that conveyed information redundant with the information conveyed in speech. Moreover, even the replacement or 'mismatched' gesture and speech combinations (those in which gesture conveyed different information from that conveyed in speech) produced by the children in Group 2 had a strong semantic coherence, suggesting that the two components may well have derived from the same source. Finally, this hypothesis can also account

for the tendency, found in both groups of children, to interpret gesture as bound to the spoken utterance and therefore to integrate the gesture and word meanings in comprehension.

Does comprehension of gesture precede production of gesture?

Four different types of gesture were used in this study, but the children appeared to understand only two of those four: the POINT gesture and the GIVE gesture. Moreover, these two gestures were essentially the only gestures (other than the HOLD-UP) found in the children's spontaneous gesture production. Thus, as a group, the children's comprehension of the particular single gestures used in this study did not exceed their production of single gestures (although some individual children did show understanding of the GIVE gesture on the comprehension test but did not spontaneously produce any GIVE gestures during visits).

In contrast, half of the children in the study were able to comprehend gesture-speech COMBINATIONS that they did not spontaneously produce. While children in both groups understood gesture-speech combinations in which gesture conveyed information different from speech, only the children in Group 2 produced instances of this type of gesture-speech combination.

Why might some children produce combinations in which the information conveyed in gesture is different from the information conveyed in speech, while others do not? It is clear from our data that these differences in production cannot be accounted for by differences in comprehension. However, mismatch between gesture and speech has been reported in the spontaneous productions of older children and found to be a good index of a child's 'readiness' to progress to a new knowledge state (Church & Goldin-Meadow, 1986; Perry *et al.* 1988, 1992). For example, Church & Goldin-Meadow (1986) showed that the children who produced gesture-speech mismatches in their explanations of a conservation task were more likely to benefit from instruction in conversation than were the children who produced gestures which matched their speech.

We speculate that the children in this study who produced combinations in which gesture conveyed information that was different from the information conveyed in speech (i.e. the children in Group 2) might be particularly 'ready' to progress to the next stage, that is, two-word speech. There is, in fact, some evidence that one-word speakers whose gestures frequently convey information different from the accompanying speech are on the verge of expanding their spoken vocabularies. Gershkoff-Stowe & Smith (1991) showed that children ranging in age from 1;4 to 1;10 who often pointed at one object while naming another (e.g. pointing at a cow while saying *dog* at a time when *dog* was a reliably known word) were in the midst of experiencing a 'naming explosion' and were particularly ready to add new words to their lexicons.

Alternatively, Group 1 and Group 2 children might simply be following two different 'styles' of gesture-speech use that bear no relation to the complexity or development of their language system. A longitudinal study following one-word speakers into the stage of two-word production would be necessary to determine whether children who produce combinations in which gesture conveys different information from speech progress more rapidly toward two-word speech than children who do not produce such combinations.

Summary

The data from this study suggest that gesture plays a significant role in the earliest stages of language development. Although the children's gestural repertoire was limited to essentially two gestures, these were frequently produced and were easily understood by the children in this study who were aged 1;6. Even at this young age, gesture appeared to form an integrated system with speech. All of the children produced gesture in combination with speech. In addition, the children were able to understand gesture when it was presented in combination with speech, not only when gesture was redundant with speech, but also when gesture substituted for speech.

Thus, gesture appears to be an interpretable source of information both for the adult experimenter probing young children's earliest communications, and for the children themselves as they observe the communications of adults around them.

REFERENCES

- Allen, R. & Shatz, M. (1983). 'What says meow?' The role of context and linguistic experience in very young children's responses to *what*-questions. *Journal of Child Language* 10, 14-23.
- Bates, E. (1976). *Language and context: the acquisition of pragmatics*. New York: Academic Press.
- Bates, E., Benigni, L., Bretherton, I., Camaioni, L. & Volterra, V. (1979). *The emergence of symbols: cognition and communication in infancy*. New York: Academic Press.
- Bekken, K. (1989). Is there 'motherese' in gesture? Unpublished doctoral dissertation, University of Chicago.
- Boswell, M. (1988). Gesture and speech in the one-word stage. Unpublished doctoral dissertation, University of Chicago.
- Carter, A. (1975). The transformation of sensorimotor morphemes into words: a case study of the development of 'more' and 'mine'. *Journal of Child Language* 2, 233-50.
- Chapman, R. (1981). Cognitive development and language comprehension in 10 to 21 month olds. In R. Stark (ed.), *Language behavior in infancy and early childhood*. New York: Academic Press.
- Church, R. B. & Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of transitional knowledge. *Cognition* 23, 43-71.
- de Laguna, G. (1927). *Speech: its function and development*. Bloomington: Indiana University Press.
- Gershkoff-Stowe, L. & Smith, L. B. (1991). Changes in pointing and labeling during the naming explosion. Poster presented at the biennial meeting of the Society for Research in Child Development, Seattle, WA.

- Goldin-Meadow, S. & Morford, M. (1985). Gesture in early child language: studies of deaf and hearing children. *Merrill-Palmer Quarterly* 31, 145-76.
- Goldin-Meadow, S., Seligman, M. E. P. & Gelman, R. (1976). Language in the two-year-old. *Cognition* 4, 189-202.
- Goldin-Meadow, S., Wein, D. & Chang, C. (in press). Assessing knowledge through gesture: using children's hands to read their minds. *Cognition and Instruction*.
- Greenfield, P. & Smith, J. (1976). *The structure of communication in early language development*. New York: Academic Press.
- Guillaume, P. (1927). Les débuts de la phrase dans le langage de l'enfant. *Journal de Psychologie* 24, 1-25.
- Huttenlocher, J. (1974). The origin of language comprehension. In R. L. Solso (ed.), *Theories in cognitive psychology*. Hillsdale, N.J.: Erlbaum.
- Kendon, A. (1972). Some relationships between body motion and speech: an analysis of an example. In A. Seigman (ed.), *Studies in dyadic communication*. New York: Pergamon Press.
- (1980). Gesticulation and speech: two aspects of the process of utterance. In M. R. Key (ed.), *Nonverbal communication and language*. The Hague: Mouton.
- Lempers, J., Flavell, E. & Flavell, J. (1976). The development in very young children of tacit knowledge concerning visual perception. *Genetic Psychology Monographs* 4.
- Leopold, W. (1949). *Speech development of a bilingual child: a linguist's record. Volume 3*. Evanston: Northwestern University Press.
- Leung, E. & Rheingold, H. (1981). Development of pointing as a social gesture. *Developmental Psychology* 17, 215-20.
- Macnamara, J. (1977). From sign to language. In J. Macnamara (ed.), *Language learning and thought*. New York: Academic Press.
- Masur, E. F. (1982). Mothers' responses to infants' object-related gestures: influences on lexical development. *Journal of Child Language* 9, 23-30.
- (1983). Gestural development, dual-directional signaling, and the transition to words. *Journal of Psycholinguistic Research* 12, 93-109.
- McNeill, D. (1985). So you think gestures are nonverbal? *Psychological Review* 92, 350-71.
- (1987). *Psycholinguistics: a new approach*. New York: Harper & Row.
- (1991). *Hand and mind*. Chicago: University of Chicago Press.
- Murphy, C. M. & Messer, D. J. (1977). Mothers, infants and pointing: a study of gesture. In H. R. Schaffer (ed.), *Studies in mother-infant interaction*. New York: Academic Press.
- Nelson, K. (1973). Structure and strategy in learning to talk. *Monographs of the Society for Research in Child Development*, No. 149, 138.
- Perry, M., Church, R. B. & Goldin-Meadow, S. (1988). Transitional knowledge in the acquisition of concepts. *Cognitive Development* 3, 359-400.
- Perry, M., Church, R. B. & Goldin-Meadow, S. (1992). Is gesture/speech mismatch a general index of transitional knowledge? *Cognitive Development* 7, 109-22.
- Petitto, L. A. (1988). 'Language' in the prelinguistic child. In F. S. Kessel (ed.), *The development of language and language researchers: essays in honor of Roger Brown*. Hillsdale, NJ: Erlbaum.
- Schaffer, H. R., Hepburn, A. & Collis, G. M. (1983). Verbal and non-verbal aspects of mothers' directives. *Journal of Child Language* 10, 337-67.
- Schnur, E. & Shatz, M. (1984). The role of maternal gestures in one-year-olds. *Journal of Child Language* 11, 29-41.
- Shatz, M. (1982). On mechanisms of language acquisition: can features of the communicative environment account for development? In E. Wanner & L. R. Gleitman (eds), *Language acquisition: the state of the art*. New York: C.U.P.
- Zinober, B. & Martlew, M. (1985). Developmental changes in four types of gesture in relation to acts and vocalizations from 10 to 21 months. *British Journal of Developmental Psychology* 3, 293-306.