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Source: *Language*, Jun., 1990, Vol. 66, No. 2 (Jun., 1990), pp. 323-355

Published by: Linguistic Society of America

Stable URL: <http://www.jstor.com/stable/414890>

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REVIEW ARTICLE†

Beyond the Input Given: The Child's Role in the Acquisition of Language

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The child's creative contribution to the language-acquisition process is potentially most apparent in situations where the linguistic input available to the child is degraded, providing the child with ample opportunity to elaborate upon that input. The children described in this paper are deaf, with hearing losses so severe that they cannot naturally acquire spoken language, and their hearing parents have chosen not to expose them to sign language. Despite their lack of usable linguistic input, these children develop gestural communication systems which share many structural properties with early linguistic systems of young children learning from established language models. This paper reviews our findings on the structural properties of the deaf children's gesture systems and evaluates those properties in the context of data gained from other approaches to the question of the young child's language-making capacity.*

This article describes our research program of the past 15 years, which investigates a unique phenomenon in language acquisition—namely, the development of language-like behavior in children who lack normal linguistic input during their early stages of acquisition. The studies encompassed in our research program bear on a number of questions in linguistic and developmental theory, in particular the innate capabilities a child brings to the language-learning situation and the role of parental input in providing sufficient structure for those capabilities to flourish. We discuss our findings and relate them to other studies addressing the child's role in language acquisition.

THE CHILD'S CONTRIBUTION TO THE LANGUAGE ACQUISITION PROCESS

1. Linguistic input has an obvious impact on the child's acquisition of language—a child who hears Swahili learns Swahili, not French or Polish. It is equally clear, however, that children (but not dogs, cats, or even chimpanzees; cf. Seidenberg & Petitto 1979) bring certain abilities to the language-learning situation that make language learning possible. A variety of approaches have recently been taken to the task of discovering the child's contribution to the language-learning process. For example, one approach explores the relationship between the linguistic input children receive and their output, in either

† [Editor's note: This essay inaugurates a type of Review Article that is new to *Language*. The editor plans to publish, from time to time, Review Articles that survey an area of linguistic research—a particular research program whose results are likely to interest many readers, as in the present instance, or a widely-discussed topic of current interest. The idea for Review Articles of this type was suggested and discussed at a recent meeting of the editor and several Associate Editors.]

* This research was supported by Grant No. BNS 8407041 from the National Science Foundation and Grant No. RO1 NS26232 from the National Institutes of Health. We thank Rachel Mayberry, Bill Meadow, and the anonymous reviewers for their helpful comments on earlier drafts of the manuscript.

semantic (e.g. Huttenlocher et al. 1983) or structural domains (e.g. Furrow et al. 1979, Gleitman et al. 1984, Newport et al. 1977). Another approach compares the spontaneous speech of children learning different languages, particularly languages that vary systematically in the semantic or structural models they provide for the learner (e.g. Clark 1976, Slobin 1985). Finally, a third approach derives conditions on the form of grammar that are then postulated to be part of the language-learning capacity of the child (e.g. Pinker 1984, Wexler 1982).

Perhaps the least ambiguous picture of the child's contribution to language learning can be obtained from situations where children go beyond the input given to them. Children routinely go beyond their input when they gain productive control of their language—that is, when they can use language in ways they have never heard it used. However, the child's creative contribution to the language-acquisition process is potentially most apparent in situations where the linguistic input available to the child is degraded, providing the child with ample opportunity to elaborate upon that input.

Bickerton 1981 proposes that creole genesis is one type of case in which children go beyond the degraded input they receive. Bickerton's proposal is controversial, in part because questions have been raised about the historical accuracy of the data upon which his claims are based (e.g. Goodman 1984, Samarin 1984, Seuren 1984). There is, however, one well-documented example of the sort of process Bickerton hypothesizes for creoles. This case study, based on developmental data in a single individual, suggests that children can introduce complexity into the language system they receive from their parents. Singleton & Newport 1987, and Singleton 1987, 1989 have described the language of a deaf child whose deaf parents' signs provided an incomplete model of the morphological structure in American Sign Language (ASL). The child, exposed only to this imperfect model of ASL, nevertheless developed a sign language with morphological structure comparable to the morphological structure developed by other deaf children exposed to complete models of ASL. This example suggests that children can produce language output which exceeds language input, and also that children have the ability to organize the pieces of language they receive to produce a linguistic system which is governed by rules not used by the adults in their environment.

A similar situation arises when deaf children (typically deaf children of hearing parents) are exposed not to ASL but rather to Manually Coded English (MCE), sign systems which map English surface structure onto the visual/gestural modality. MCE systems were invented by educators to teach English to deaf children and thus are not 'natural' language systems spontaneously developed by language users. MCE relies on a lexicon heavily borrowed from ASL. However, unlike ASL morphology, in which simultaneous spatial devices serve as morphological markers, morphology in MCE is sequential rather than simultaneous and utilizes invented signs that follow in a one-to-one fashion the morphological structure of English. There is some doubt that the structure of English can be successfully incorporated into the signed medium. Indeed, deaf children exposed only to MCE have been found to alter the code, innovating forms that systematically use space to convey meaning, as do many of the

grammatical devices of ASL (Gee & Goodhart 1985, Goodhart 1984, Livingston 1983, S. Supalla 1990, Suty & Friel-Patti 1982). Thus, when provided with an input that may be difficult to process, children are capable of altering that input and constructing a rule-governed system of their own.

An even more extreme example of the child's ability to go beyond the input comes from our work on children who are not exposed to usable input from any established language. The children we have studied are deaf with hearing losses so severe that they cannot naturally acquire oral language. In addition, these children are born to hearing parents who have chosen not to expose them to a conventional sign language such as ASL or MCE. Despite their lack of usable linguistic input, either signed or spoken, these deaf children develop gestural communication systems which share many—but not all—of the structural properties of the early linguistic systems of children exposed to established language models. A primary goal of our research has been to describe the structural properties of early child language that can be found in the gestural systems developed by deaf children without the benefit of a conventional language model.

At the outset, we recognize that, although the children in our studies are not exposed to a model of an established language, they are exposed to the spontaneous gestures their hearing parents use when speaking to them (as are children of hearing parents; cf. Shatz 1982). These gestures could conceivably serve as input to the deaf children's gestural systems, so they must be the background against which the children's gestural accomplishments are evaluated. A second goal of our research, therefore, has been to determine the origin of the structural properties found in the deaf children's gestural systems—specifically, to discover which aspects of these structures can be traced to the gestural input provided by the children's hearing parents and which aspects go beyond this input.

The primary focus of this paper, then, is an assessment of the nature of the child's contribution to the language-acquisition process. We will begin by reviewing our own findings on the structural properties of the gesture systems produced by deaf children of hearing parents, and then by comparing the gestures produced by these deaf children to the gestures produced spontaneously by the children's own hearing parents. Finally, we will evaluate the structural properties found in our deaf children's gestures in the context of data gained from other approaches to the question of the child's language-making capacity.

BACKGROUND ON DEAFNESS AND LANGUAGE LEARNING

2.1. GENERAL BACKGROUND. The sign languages of the deaf are autonomous languages which are not based on the spoken languages of hearing cultures (Bellugi & Studdert-Kennedy 1980, Klima & Bellugi 1979, Lane & Grosjean 1980). A sign language such as ASL is a primary linguistic system passed down from one generation of deaf people to the next and is a language in the full sense of the word. Like spoken languages, ASL is structured at syntactic (Fischer 1974, Liddell 1980, Lillo-Martin 1986, Padden 1983), morphological (Fischer 1973, Fischer & Gough 1978, Klima & Bellugi 1979, Newport 1981,

T. Supalla 1982, Supalla & Newport 1978), and 'phonological' levels of analysis (Battison 1974, Coulter 1986, Lane et al. 1976, Liddell 1984, Liddell & Johnson 1986, Padden & Perlmutter 1987, Sandler 1986, Stokoe 1960, Wilbur 1986).

Deaf children born to deaf parents and exposed from birth to a conventional sign language such as ASL have been found to acquire that language naturally; that is, these children progress through stages in acquiring sign language similar to those of hearing children acquiring a spoken language (Caselli 1983, Hoffmeister 1978, Hoffmeister & Wilbur 1980, Kantor 1982, Newport & Ashbrook 1977, Newport & Meier 1985). Thus, in an appropriate linguistic environment—in this case a signing environment—deaf children are not handicapped with respect to language learning.

However, 90% of deaf children are not born to deaf parents who could provide early exposure to a conventional sign language. Rather, they are born to hearing parents who, quite naturally, tend to expose their children to speech (Hoffmeister & Wilbur 1980). Unfortunately, it is extremely uncommon for deaf children with severe to profound hearing losses to acquire the spoken language of their hearing parents naturally, that is, without intensive and specialized instruction. Even with instruction, deaf children's acquisition of speech is markedly delayed when compared either to the acquisition of speech by hearing children of hearing parents or to the acquisition of sign by deaf children of deaf parents. By age 5 or 6, and despite intensive early training programs, the average profoundly deaf child has only a very reduced oral linguistic capacity (Conrad 1979, K. Meadow 1968).

In addition, unless hearing parents send their deaf children to a school in which sign language is used, these children are not likely to receive conventional sign-language input. Under such inopportune circumstances, these deaf children might be expected to fail to communicate at all, or perhaps to communicate only in nonsymbolic ways. This turns out not to be the case.

Previous studies of deaf children of hearing parents have shown that these children spontaneously use gestures (referred to as 'home signs') to communicate, even if they are not exposed to a conventional sign-language model (Fant 1972, Lenneberg 1964, Moores 1974, Tervoort 1961). Given a home environment in which family members communicate with each other through many different channels, one might expect that the deaf child would exploit the accessible modality (i.e. the manual modality) for purposes of communication. However, given that no language model is present in the child's accessible modality, one might NOT expect that the child's communication would be structured in language-like ways.

Our work has focused particularly on the structural aspects of deaf children's gestures and has attempted to determine whether any of the linguistic properties found in natural child language can also be found in those gestures. We have analyzed the gestures of ten deaf children of hearing parents and have found each child's gestures to be structured at several different levels. We focus here on three aspects of structure in the deaf child's gestures, describing each in turn: lexicon, syntax, and morphology.

2.2. BACKGROUND ON THE SAMPLE. The ten children in our sample ranged in age from 1;4 (years;months) to 4;1 at the time of the first interview and from 2;6 to 5;9 at the time of the final interview. The children were videotaped in their homes during play sessions with their hearing parents or the experimenter every 2 to 4 months for as long as each child was available (the number of observation sessions per child ranged from 2 to 16). Six of the children lived in the Philadelphia area and four in the Chicago area.

The children were all born deaf to hearing parents and sustained severe (70–90 dB) to profound (>90 dB) hearing losses. Even when wearing a hearing aid in each ear, none of the children was able to acquire speech naturally. In general, a child with a severe hearing loss is unable to hear even shouted conversation and cannot learn speech by conventional means. A child with a profound loss can hear essentially no conversation and hears only occasional very loud sounds which may be perceived more as vibrations than sound patterns. Amplification serves to increase awareness of sound but often does not increase the clarity of sound patterns (Mindel & Vernon 1971, Moores 1982).

Two of the ten children were not attending any educational program at the time of our studies; the remaining eight were being educated in oral schools (2 in one school, 3 in another, and the remaining 3 in three different schools). Each of the schools advocated an oral method of deaf education which offered early and intense training in sound sensitivity, lipreading (or speechreading), and speech production, and which discouraged the use of conventional sign language with the child. It is important to note that the information one gets from reading visual cues off a speaker's lips is not enough to allow severely and profoundly deaf children to learn spoken language (see Conrad 1979, Farwell 1976, Summerfield 1983). Visual cues are generally ambiguous with respect to speech: the mapping from visual cues to words is one to many. In order to constrain the range of plausible lexical interpretations, other higher-order classes of information (e.g. the phonological, lexical, syntactic, semantic, and pragmatic regularities of a language) must come into play during speechreading. The most proficient speechreaders are those who can use their knowledge of the language to interpret an inadequate visual signal (Conrad 1977). In fact, postlingually deafened individuals (people who had knowledge of a language before losing their hearing) are generally more proficient speechreaders than individuals who have been deaf from birth (Summerfield 1983). Since speechreading requires knowledge of a language to succeed, it cannot provide all the input necessary for a severely to profoundly deaf child to learn language. At the time of our studies, none of the children in our study had made significant progress in acquiring spoken English.¹

In addition, none of the children in our sample had been exposed to con-

¹ For example, only 4% of the communications the children produced contained meaningful vocalizations; see Goldin-Meadow & Mylander (1984a:42–43) for further discussion of the children's progress in spoken English. Two additional deaf children of hearing parents were eliminated from the sample because they had been making good progress in acquiring spoken English, suggesting that speech was relatively accessible to these children.

ventional sign language. Consistent with the oral-education philosophy, sign language was not used in any of the schools these children attended (indeed, none of the teachers knew sign language, nor did any of the other children in the classroom). Moreover, neither the children's hearing parents nor their hearing siblings knew sign language.

THE DERIVATION OF CODING CATEGORIES

3. How does one begin a description of the deaf child's gesture system? The problem lies in entering the system. Because there is no established language model toward which the deaf child's system is developing, there are no hints from a conventional system that might guide initial descriptions. Consequently, the description procedure necessarily becomes a bootstrap operation. It begins with preliminary decisions on how to categorize the gestures produced by deaf subjects (e.g. how to isolate gestures from the stream of motor behavior, how to segment those gestures, and how to assign them meanings).

Our preliminary coding categories were based on two sources. The first was the corpus of descriptions of spoken language, particularly child language, and the growing number of descriptions of conventional sign languages. The second source was our intuitions about the motoric forms and the meanings of the gestures produced by deaf subjects.

Having established preliminary coding categories (discussed below), we began to utilize them while transcribing videotapes. We tested the usefulness of our tentative categories in two ways. First, we asked if the categories were reliable, and we established reliability by comparing the judgments of one experimenter and a second coder who was not at the original taping sessions. The agreement scores between two coders were found to be quite high (between 87% and 100%, depending on the coding category), confirming category reliability.

In the second test of our category definitions, we asked if these particular categories resulted in coherent descriptions of the deaf child's gesture system. The claim made here is that, if a description based on these particular coding categories is coherent, this fact is evidence of the usefulness of the categories themselves. Consider the following example. Suppose we tentatively apply the semantic categories 'patient' (object acted on) and 'act' to the deaf child's gestures. If we then discover a pattern based on those categories (e.g. a gesture-ordering rule following, say, a patient-act pattern), we ask whether the pattern has both retrospective validity and prospective predictive value. If so, we have evidence that the particular categories *PATIENT* and *ACT* are useful in descriptions of the deaf child's system. The existence of the pattern confirms the utility of the categories, since the former is formulated in terms of the latter.

There is, of course, the possibility that these patterns and categories are products of the experimenter's mind rather than the child's. However, our study is no more vulnerable to this possibility than are studies investigating young hearing children who are learning spoken languages. Adult experimenters may be incapable of finding anything but language-like structures in a child's communication (for a discussion of this point, see Goldin-Meadow &

Mylander 1984a:18–26). Although the problem can never be completely avoided, the following assumption allows us to proceed: if a category turns out to ‘make sense of’, or organize, the child’s communications (e.g. by forming the basic unit of a predictable pattern), we are then justified in isolating that category as a unit of the system and in attributing that category to the child. Thus, the consistency of the results described in §§4–6 and in our previous work lends credence to our coding categories.

Two final methodological points are worth noting in regard to our coding categories. First, the coding categories described below were devised on the basis of data from the Philadelphia children; however, these same categories, when applied to the Chicago data, continued to yield coherent and systematic structures. And second, our coding techniques do not inevitably unearth structure in spontaneous gestures (see §7, which shows that the spontaneous gestures produced by the deaf children’s hearing mothers, when analyzed with the coding techniques described below, do not form a linguistic system comparable to the children’s).

3.1. IDENTIFYING A GESTURE. Our first task is to isolate communicative gestures from the stream of ongoing motor behavior. The problem here is to discriminate acts that communicate indirectly (e.g. pushing a plate away, which indicates that the eater has had enough) from those acts whose sole purpose is to communicate symbolically (e.g. a ‘stoplike’ movement of the hands produced in order to suggest to the host that another helping is not necessary). We do not consider every nudge or facial expression produced by the deaf subjects to be a communicative gesture (no matter how much information is conveyed). Consequently, we are forced to develop a procedure that isolates only those acts used for deliberate communication.

Lacking a generally accepted behavioral index of deliberate or intentional communication (see MacKay 1972 for discussion), we decided that a communicative gesture must meet both of the following criteria. First, the motion must be directed to another individual. This criterion is satisfied if the child attempts to establish eye contact with the communication partner (the criterion was strictly enforced unless there had been recent previous communication with eye contact such that the child could assume the continued attention of the partner).² Second, the gesture must not be a direct motor act on the partner or on some relevant object. As an example, if the child attempts to twist open a jar, s/he is not considered to have made a gesture for ‘open’, even if in some sense s/he is, by this act, trying to communicate to the experimenter that s/he needs help opening the jar. But if the child makes a twisting motion in the air, with eyes first on the experimenter to establish contact, we consider the motion

² Strict application of this criterion breaks down in the few instances where one of the children in our sample was found to gesture with no one else around, that is, as though he were gesturing to himself. The fact that this child was found to use his gestures to ‘talk’ to himself indicates that gesture can take on other functions of language in addition to communication with others; see also §4.1, where evidence is presented that this same deaf child was able to use his gestures metalinguistically, that is, to refer to his own gestures.

to be a communicative gesture. Once isolated, gestures were recorded in terms of three dimensions commonly used to describe signs in ASL (Stokoe 1960): shape of the hand, movement of the hand or body, and location of the hand with respect to places on the body or in space.

3.2. SEGMENTING GESTURE STRINGS. We next decided on the units appropriate for describing combinations of gestures. Here again we borrowed a criterion often used in studies of ASL: relaxation of the hand after a gesture or series of gestures was taken to signal the end of a string, that is, to demarcate a sentence boundary. For example, if a child pointed to a toy and then, without relaxing the hand, pointed to a table, the two pointings were considered 'within a string'. The same two pointings, interrupted by a relaxation of the hand, would be classified as two isolated gestures.

This criterion received retrospective validation from our subsequent analyses. We determined the boundaries of gesture strings on the basis of relaxation of the hand, and then examined the resulting strings to see if they had sentence-like qualities. We found that the deaf children's gesture strings, when isolated according to this criterion, resembled the early sentences of children learning conventional languages in three respects: (1) the strings were used to express the same types of semantic relations as are typically expressed in early child language (see §5.1); (2) the strings were characterized by the same types of structural devices as are typically found in early child language (§5.2); and (3) the developmental onset of the strings used to express single propositions and multipropositions fit well with the onset of simple and complex sentences in early child language (§5.4). We therefore felt justified in continuing to use relaxation of the hand to determine boundaries and in calling the deaf children's gesture strings 'sentences'.

3.3. ASSIGNING MEANING TO GESTURES. Our subjects produced three types of gestures. **DEICTIC** gestures typically were pointing gestures that maintained a constant kinesic form in all contexts. These deictics were used predominantly to single out objects, people, places, and the like in the surroundings. In contrast, **CHARACTERIZING** gestures were stylized pantomimes whose forms varied with the intended meaning of each gesture (e.g. a fist pounded in the air as someone was hammering or two hands flapping in the presence of a pet bird). Finally, **MARKER** gestures were typically head or hand gestures (e.g. nods and headshakes or one finger held in the air signifying 'wait') that are conventionalized in our culture and that the children used as modulators (e.g. to negate, affirm, and doubt).

We next assigned lexical meanings to both deictic and characterizing gestures (markers are not included in the analyses presented here). The problems we faced were comparable to those that arise in assigning lexical meanings to a hearing child's words. Consider an English-speaking child who utters *duck walk* as a toy Donald Duck waddles by. Adult listeners assume that, since the child used two distinct phonological forms (*duck* and *walk*), s/he intended to describe two distinct aspects of the event (the feathered object and the walking action). Moreover, we assume that the child's noun *duck* refers to the object, and that

the verb *walk* refers to the action of the object—that is, that the child’s lexical meanings for the words *duck* and *walk* coincide with adult meanings for these words. In general, we tend to assume that nouns refer to objects, people, places, and the like, and that verbs refer to actions, processes, and so forth. This decision, although difficult to justify (for discussion, see Braine 1976, Dromi 1987), is bolstered by data from the child’s language system taken as a whole. To the extent that the child has mastered other aspects of the adult system that are based on the noun-verb distinction (e.g. verb agreement), s/he can plausibly be said to have mastered the distinction in the instance of lexical meanings.

For our deaf subjects we must also make relatively arbitrary assumptions at this stage of assigning lexical meanings, but in this case we have no adult language model to guide us. As a result, we have chosen to use gesture FORM as a basis for assigning lexical meanings to the deaf children’s gestures. We assume that deictic gestures (e.g. pointing at the duck) refer to objects, people, and places, and that characterizing gestures (e.g. walking motions produced by the hands) refer to actions and attributes. These decisions are elaborated in the next section and are justified in detail in Goldin-Meadow & Mylander (1984a:19–26).

Although many of our coding decisions are arbitrary, they are not unmotivated. For example, in deciding that points denote objects, people, and places, we followed researchers of child language in ASL (e.g. Hoffmeister 1978, Kantor 1982) who treat points in the early sentences of deaf children acquiring ASL from their deaf parents as object-referring. Of course, it is likely that one could make a different set of coding decisions (equally arbitrary but motivated in their own right) that would result in a description of the deaf children’s gestures that was less structured than the description presented below. In similar fashion, one could choose to describe the hearing child’s sentences in such a way that they appear to be less structured. But what is to be gained by making a different set of coding decisions (for example, by excluding pointing gestures from the analyses, or by ignoring the boundaries demarcated by relaxation of the hands in the deaf children’s gesture systems)? As we will show, structured patterns are undeniably present in the deaf children’s gesture systems if the systems are described in terms of our coding categories. We believe that the reasonableness of the coding decisions we have made is supported by two facts: our coding decisions yield coherent patterns with prospective validity, and these coherent structures resemble the structures of early child language, both spoken and signed.

LEXICON IN THE GESTURES OF DEAF CHILDREN OF HEARING PARENTS

4.1. POINTING GESTURES. At the outset, it is important to note that pointing gestures and words differ fundamentally in terms of the referential information each conveys. The deictic pointing gesture, unlike a word, serves to direct a communication partner’s gaze toward a particular person, place, or thing; thus, the gesture explicitly specifies the location of its referent in a way that a word (even a pro-form) never can. The pointing gesture does not, however, specify what the object is; it merely indicates where the object is. That is, the pointing

gesture is 'location-specific' but not 'identity-specific' with respect to its referent. Single words, by contrast, can be identity-specific (e.g., *lion* and *ball* serve to classify their respective referents into different sets), but not location-specific, unless the word is accompanied by a pointing gesture or other contextual support.

Despite this fundamental difference between pointing gestures and words, the deaf children's pointing gestures were found to function like the object-referring words of hearing children in two respects. First, the referents of the points in the deaf children's gestured sentences encompassed the same range of object categories (in approximately the same distribution) as the referents of nouns in hearing children's spoken sentences (Feldman et al. 1978, Goldin-Meadow & Mylander 1984a:20).³ Second, the deaf children combined their pointing gestures with other points and with characterizing gestures; if these points are considered to function like nouns and pronouns, the deaf children's gesture combinations turn out to be structured like the early sentences of children learning conventional languages (see §5.2). Thus, the deaf children's pointing gestures appear to function as part of a linguistic system.

In addition, the deaf children used their pointing gestures in ways that went beyond merely directing the gaze toward a particular object. The children primarily used their pointing gestures to refer to real-world objects in the immediate environment (e.g., the child pointed at a jar of bubbles, followed by a 'blow' characterizing gesture, to request that the bubbles be blown). However, the children also used their pointing gestures to refer to objects that were not present in the here-and-now, and did so by pointing at a real-world object that was similar to the (absent) object they intended to refer to (e.g., the child pointed at an empty jar of bubbles, followed by a 'blow' gesture, to request that the absent full jar of bubbles be blown). We examined pointing gestures in detail in one of our deaf subjects (Goldin-Meadow et al. 1990), and found that this child could extend his use of points even farther beyond the here-and-now by pointing at an arbitrary location in space set up as a place-holder for an absent intended referent (e.g., the child pointed at a spot on his own gesture—a 'round' gesture representing the shape of a Christmas-tree ball—to refer to the hook typically found at that spot on Christmas tree ornaments). This child was found to use points to indicate objects in the immediate context when he was first observed at age 2;10; he first used his points to indicate objects that were not present in the here-and-now at age 3;3, and began using points to indicate arbitrary locations set up as place-holders for objects at age 4;10. Hoffmeister 1978 reports a similar developmental pattern, from points at real-world objects to 'semi-real-world' objects to arbitrary loci, in deaf children who have been exposed to a conventional sign language (ASL) from birth.

Moreover, the child whose points we have studied extensively was also found

³ One might object to coding a pointing gesture as though it were a noun rather than a pronoun, e.g. to coding a point as 'dog' rather than 'this'. However, it is important to realize that whether a point is coded as 'dog' or 'this' makes no difference in our syntactic analyses (see §5.2); the crucial category for these analyses is the thematic role (e.g. patient or actor) played by the object indicated by the pointing gesture.

to use his pointing gestures to refer to his own gestures. For example, to request a Donald Duck toy that the experimenter held behind her back, the child pursed his lips to imitate Donald Duck's bill, then pointed at his own pursed lips and pointed toward the Donald Duck toy behind the experimenter's back. When offered a Mickey Mouse toy, the child shook his head, pursed his lips and again pointed at his own pursed lips (see also the above example in which he pointed at his own 'round' gesture). Thus, the child was able to use his pointing gestures metalinguistically, suggesting not only that pointing gestures formed an integral part of his linguistic system, but also that he could distance himself from his own gestures and treat them as objects to be reflected on and referred to.

4.2. CHARACTERIZING GESTURES. The characterizing gesture, which is the lexical item the deaf children used to denote actions and attributes, also differs somewhat from the words or signs typically used by young language learners exposed to conventional language models. The form of the deaf children's characterizing gesture captures an aspect of its referent and, in this respect, is distinct both from the far less transparent verb and adjective word forms that hearing children use to denote actions and attributes and from the early sign forms of deaf children acquiring ASL—since most of these are not iconic (Bonvillian et al. 1983) or, if iconic from an adult's point of view, are not recognized as iconic by the child (Schlesinger 1978). Note, however, that, in contrast to their location-specific pointing gestures, the deaf children's characterizing gestures resemble hearing children's words in that the characterizing gesture (via its iconicity) can specify the identity of its referent.

Although all of the deaf children's characterizing gestures were iconic, the gestures differed in the transparency of the relation between the form of the gesture and the intended referent. For example, the form of some of the gestures was based on an act associated with the act or attribute the child intended to refer to (e.g., the child arced a hand back and forth in the air as though conducting to refer to the act of singing, or put two palms together in front of the chest as though praying to refer to the act of going to school, which was an oral Catholic school where each day began with prayer). In other instances, the children used stereotyped actions commonly found in our culture as the basis for their gestures—e.g., one child held his nose to indicate that an object was smelly, or rubbed his belly to indicate that an object was tasty; another child held two fists together side-by-side and then broke the fists apart to indicate that an object was or had been broken, regardless of the motion that was actually used to break the objects; another extended her palm to request the transfer of an object, not just to her own hand, but to other people and to other locations. Lexical meaning for these less-transparent gestures was determined on the basis of extralinguistic context, which is the procedure followed in most studies of spoken language learning (cf. Bloom 1970).

The majority of the deaf children's gestures were, however, quite transparent, with the motion or handshape of the gesture reflecting the action or attribute the child intended to refer to. For these gestures we inferred a probable meaning on the basis of extralinguistic context but then used the form of the gesture to further constrain our meaning assignments. For example, one child

held a fist near his mouth and made chewing movements to comment on his sister eating snacks; this gesture was assigned the meaning 'eat'. Another child moved her hand forward in the air to describe the path of a moving toy, and this gesture was assigned the meaning 'go'. Similarly for attribute gestures, as when one child formed a round shape with the hand to describe a Christmas tree ornament; basing the meaning of the gesture on its form, we assigned the meaning 'round' to the gesture.

The form of the gesture and its context were also used to classify action gestures as either transitive or intransitive. If the intended referent of a gesture involved action on an object (manipulating it, touching it, holding it, changing it, or moving it), the gesture was considered transitive. If, however, the intended referent of the gesture involved an action in which a person or object moved on its own (either moving in place or moving to a new location), the gesture was considered intransitive.⁴ Often the form of the gesture was the crucial determinant in deciding about transitivity. For example, consider a situation in which the child pushed a toy truck and then watched the truck go forward on its own (a child learning English might describe this situation with the ambiguous word *move*, meaning either 'I move the truck' or 'the truck moves'). The way the deaf child chose to represent this event in a characterizing gesture determined whether we called that gesture a transitive act or an intransitive act. If the child moved a hand in a short arc representing the pushing action done on the truck, the gesture was classified as the transitive act 'push'. If, however, the child moved a hand forward in a linear path representing the action of the truck, the gesture was classified as the intransitive act 'go'.

SYNTAX IN THE GESTURES OF DEAF CHILDREN OF HEARING PARENTS

5.1. PREDICATE STRUCTURE. The deaf children in our studies combined their gestures into strings that functioned in a number of respects like the sentences of early child language. First, the children's gesture sentences expressed the semantic relations typically found in early child language (in particular, action and attribute relations), with characterizing gestures representing the predicates and pointing gestures representing the arguments playing different thematic roles in those semantic relations (Goldin-Meadow & Mylander 1984a:26–29, 58–59). For example, one child produced a pointing gesture at a bubble jar (representing the argument playing the patient role) followed by the characterizing gesture 'twist' (representing the act predicate) to request that the experimenter twist open the bubble jar. Another child produced a pointing gesture at a train (representing the argument playing the actor role) followed by the

⁴ A number of activities cannot easily be classified as either transitive or intransitive using these criteria, e.g. the activity of seeing or noticing. However, the children rarely produced gestures for activities of this sort, and, when they did, the gestures were considered ambiguous with respect to this dimension. In addition, note that intransitive activities were defined in terms of spontaneous motion, a criterion which excludes more static activities that tend to be intransitive in English (e.g. 'lying'). The few gestures the children produced for activities of this sort were classified as attributes because the form of each gesture reflected a static property of an object or person (e.g. a horizontal palm used to indicate lying flat).

characterizing gesture ‘circle’ (representing the act predicate) to comment on the fact that a toy train was circling on the track.

In addition, the predicates in the deaf children’s sentences were comparable to the predicates of early child language in having underlying frames or structures composed of 1, 2, or 3 arguments (Goldin-Meadow 1985:215–19, Feldman et al. 1978:385–8). For example, all of the children produced ‘transfer’ or ‘give’ gestures with an inferred predicate structure containing 3 arguments—the actor, the patient, and the recipient⁵ (e.g., you/sister give duck to her/Susan). The children also produced two types of 2-argument predicates: transitive gestures such as ‘eat’ with a predicate structure containing the actor and patient (e.g., you/Susan eat apple), and intransitive gestures such as ‘go’ with a predicate structure containing the actor and recipient (e.g., you/mother go upstairs). Finally, the children produced gestures such as ‘sleep’ or ‘dance’ with a 1-argument predicate structure containing only the actor (e.g., you/father sleep).

We attributed these 1-, 2-, and 3-argument predicate structures to the deaf children’s gestures on the basis of two types of evidence. First, we found that each child, at some time in his or her repertoire, produced gestures for all of the arguments associated with a particular predicate structure (see Bloom [1970], who first used this procedure to justify assigning complex underlying structure to two-word strings in hearing children; see also Goldin-Meadow 1985:230–38 for further discussion of this procedure of ‘rich interpretation’ and its application to the deaf children’s gesture systems). For example, one child produced the following different two-gesture sentences, all conveying the notion of transfer of an object: ‘cookie give’ (patient-act), ‘sister David’ (actor-recipient), ‘give David’ (act-recipient), ‘duck Susan’ (patient-recipient). By overtly expressing the actor, the patient, and the recipient in this predicate context, the child exhibited knowledge that these 3 arguments are associated with the transfer predicate (see Goldin-Meadow 1985:216 for additional examples).

The second type of evidence for predicate structure in the deaf children’s gestures came from the relative probability that a given argument or predicate would be gestured in a two-gesture sentence. Most of the children’s sentences contained only two gestures; thus, for most sentences, the child was not likely to produce gestures for all of the arguments associated with a particular predicate. The likelihood that a gesture would be produced depicting any given argument should depend on the number of arguments that could be gestured in the predicate. If we are correct in assigning structures of 1, 2, or 3 arguments to different predicates, the probability that a given argument, for example the actor, would be gestured in a 3-argument predicate should be lower than the probability that the actor would be gestured in a 2-argument predicate, simply because there is more ‘competition’ for the limited number of surface slots for

⁵ We use the term *RECIPIENT* to refer to the destination of predicates such as ‘go’ or ‘put’, whether that destination is animate (‘go to Mother’) or inanimate (‘go to the table’). The children do not appear to distinguish animate from inanimate recipients (i.e., both tend to occupy the same position in a two-gesture sentence). Traditionally, the term *GOAL* is used if a term encompassing both animate recipients and inanimate destinations is needed. We continue to use the term recipient here to be consistent with previously-published descriptions of the deaf children’s gesture systems.

a 3-argument predicate than there is for a 2-argument predicate (so, for instance, the actor in a 'give' predicate should be less likely to be gestured than the actor in an 'eat' predicate). In turn, the probability that the actor would be gestured in a 2-argument predicate should be lower than the probability that the actor would be gestured in a 1-argument predicate (e.g., the actor in an 'eat' predicate should be less likely to be gestured than the actor in a 'dance' predicate). This predicted production-probability pattern was found for the actor, for the patient, and for the act in the gesture sentences of the six Philadelphia deaf children (Goldin-Meadow 1979) and the four Chicago deaf children (Goldin-Meadow 1985), providing evidence for predicate structure in the gesture systems of all ten of our deaf subjects.

5.2. ORDERING AND PRODUCTION PROBABILITY RULES. The deaf children's gesture sentences were structured on the surface, as are the sentences of early child language (Goldin-Meadow & Feldman 1975, 1977, Goldin-Meadow & Mylander 1984a:35–38). The sentences the children produced were found to conform to regularities of two types: ordering regularities and production-probability regularities. Moreover, the particular structural regularities found in the children's sentences showed considerable consistency across the ten children in the sample.

Ordering regularities were based on the position that a gesture for a particular thematic role tended to occupy in a sentence. The children tended to order gestures for patients, acts, and recipients in a consistent way in their two-gesture sentences. The following three ordering patterns were found in many, but not all, of the children's two-gesture sentences (Goldin-Meadow & Mylander 1984a:35–36): PATIENT-ACT (e.g., the gesture for the patient 'cheese' preceded the gesture for the act 'eat'), PATIENT-RECIPIENT (e.g., the gesture for the patient 'hat' preceded the gesture for the recipient 'cowboy's head'), and ACT-RECIPIENT (e.g., the gesture for the act 'move-to' preceded the gesture for the recipient 'table'). In addition, although most of the children did not produce enough sentences containing gestures for the actor to enable us to discern a consistent order, two of the children did exhibit an ordering pattern for the actor (primarily for the intransitive actor, but also for the few transitive actors they produced): the gesture for the actor (e.g. 'mother') preceded the gesture for the act (e.g. 'goes').

As described above, production probability is the likelihood that a particular thematic role will be gestured in a sentence. Unlike the analysis in §5.1, where we compared the production probability of a given thematic role (e.g. the patient) across different predicate frames, in this analysis we compare the production probability of different thematic roles (e.g. the patient vs. the actor) in predicate frames of the same size. If the children were randomly producing gestures for the thematic roles associated with a given predicate, they would, for example, be equally likely to produce a gesture for the patient as for the actor in a sentence about eating. We found, however, that the children were not random in their production of gestures for thematic roles—in fact, likelihood of production was found to distinguish among thematic roles. We found, in particular, that all ten of the children were more likely to produce a gesture

for the patient, e.g. 'cheese', in a sentence about eating than to produce a gesture for the actor, 'mouse' (Goldin-Meadow & Mylander 1984a:37). Note that this particular production probability pattern tends to result in two-gesture sentences that preserve the unity of the predicate, i.e., patient + act sentences (akin to OV in conventional systems) were more frequent in our deaf children's gestures than actor + act sentences (akin to SV in conventional systems).

In addition, nine of the ten children produced gestures for the intransitive actor (e.g. the mouse in a sentence describing a mouse running in his hole) as often as they produced gestures for the patient (e.g. the cheese in a sentence describing a mouse eating cheese), and far more often than they produced gestures for the transitive actor (e.g. the mouse in a sentence describing a mouse eating cheese; Goldin-Meadow & Mylander 1984a:36–38). This production-probability pattern is an analogue of the structural case-marking patterns of ergative languages in that the intransitive actor is treated like the patient rather than like the transitive actor. (Note, however, that in conventional ergative systems it is the transitive actor which is marked, whereas in the deaf children's gesture systems the transitive actor tends to be omitted and, in this sense, could be considered unmarked; cf. Dixon 1979, Silverstein 1976.)⁶

The ergative pattern found in the deaf children's gestures could reflect a bias on the part of the child toward the affected object of an action. In an intransitive sentence such as *you go to the corner*, the intransitive actor *you*, in some sense, has a double meaning. On the one hand, *you* refers to the goer, the actor, the effector of the going action. On the other hand, the *you* refers to the gone, the patient, the affectee of the going action. At the end of the action, *you* both *have gone* and *are gone*, and the decision to emphasize one aspect of the actor's condition over the other is arbitrary. By treating the intransitive actor like the patient, the deaf children appear to be highlighting the affectee properties of the intransitive actor over the effector properties.

5.3. COMPLEX SENTENCES. We determined the boundaries for a string of gestures on the basis of gesture form (using relaxation of the hand as the criterion, as described in §3.2) and then determined the number of propositions conveyed within that gesture string.⁷ We found that all ten of the deaf children in our sample generated complex sentences containing at least two propositions (Goldin-Meadow 1982, Goldin-Meadow & Mylander 1984a:39–42). The propositions conjoined in the children's complex sentences often had a temporal

⁶ In addition to an ergative-like pattern in production probability, the one child who produced a sufficient number of sentences with transitive actors to allow us to determine a pattern also showed an ergative pattern in the way he ordered his gestures. He tended to produce gestures for the patient and the intransitive actor BEFORE gestures for the act in his two-gesture sentences, but gestures for the transitive actor AFTER gestures for the act. This one child thus treated patients and intransitive actors alike, and distinct from transitive actors, not only with respect to production probability but also with respect to gesture order (Goldin-Meadow & Mylander 1984a:39).

⁷ Note that, because we classify all characterizing gestures as predicates (§4.2.), when a characterizing gesture is combined with another characterizing gesture within a single string, two predicates (and therefore two propositions) are conveyed within that string, and the string is consequently classified as a complex sentence.

relationship to one another; these sentences either described a sequence of events or requested that a sequence of events take place. For example, one child pointed at a tower and produced a 'hit' gesture and then a 'fall' gesture to comment on the fact that he had hit [act₁] the tower and that the tower had fallen [act₂]. The children also produced complex sentences conveying propositions which were not ordered in time. For example, one child pointed at Mickey Mouse and produced a 'swing' gesture and then a 'walk' gesture to comment on the fact that Mickey Mouse both swings on the trapeze [act₁] and walks [act₂].

In English, when two propositions are conjoined, there is often at least one element of each of the propositions that is redundant or 'shared' in both. For example, in the sentence *Mary cut the apples and John ate the apples*, *apples* is shared by both propositions (the second *apples* could of course be replaced by *them*; this overtly marks the property as shared in surface structure). Some of the complex sentences that the deaf children produced contained propositions with no redundant or shared elements (e.g., one child produced a 'sip' gesture, pointed at a toy cowboy, pointed at a toy soldier, and then produced a 'beat' gesture, to comment on the fact that the cowboy sips a straw and the soldier beats a drum). However, the children also produced a number of complex sentences whose underlying propositions did contain shared or redundant elements. For example, in some of these sentences the actor was the same or shared across the two propositions (e.g. a 'climb' gesture, followed by a 'sleep' gesture, followed by a point at a horse, to comment on the fact that the horse climbed the house and then the horse slept), and in others the predicate was shared across the two propositions (e.g. a point at a toy pear, followed by a point at a toy banana and a side-to-side headshake, followed by a 'roll' gesture, to indicate that the pear should roll forward but the banana should not roll forward).

Note that complex sentences with shared elements can be represented either as the conjunction of two full propositions, i.e. sentential conjunction, in which the shared element appears twice in the propositions underlying the sentence, once in each proposition (e.g., 'Mickey Mouse swings and Mickey Mouse walks'), or as the conjunction of parts of propositions, i.e. phrasal conjunction, in this case predicate conjunction, in which the shared element appears only once (e.g., 'Mickey Mouse swings and walks'). In an analysis of the complex sentences of the Philadelphia subjects, we found evidence for phrasal conjunction in the children's sentences with shared elements (Goldin-Meadow 1982). In particular, we found that production probability of a particular thematic role, e.g. the actor, decreased systematically with an increase in the number of elements in the propositions underlying the sentence ONLY IF the shared element was allocated one slot in the propositional structure rather than two—that is, if Mickey Mouse were counted once (Mickey Mouse-swings-walks) rather than twice (Mickey Mouse-swings-Mickey Mouse-walks; see Goldin-Meadow 1982, 1987 for further discussion).

5.4. DEVELOPMENTAL PATTERN. Two of the ten children in our sample began producing two-gesture sentences sometime during our observations (the re-

maining eight children were already combining gestures into sentences when the study began). During their initial observation sessions these two children produced only one gesture at a time, either a single point or a single characterizing gesture. They began producing two-gesture sentences at 1;6 and 2;5—ages comparable to the onset of two-word sentences in hearing children learning English (Brown 1973) and slightly later than the onset of two-sign sentences in deaf children learning ASL (Bonvillian et al. 1983).

Moreover, four of the children in the sample began producing complex gesture sentences conveying more than one proposition (see §5.3 for examples) sometime during our observations (the other six children were already producing complex sentences at the start of the study). Three of these children produced complex sentences for the first time at ages 2;2, 2;2, and 2;5; the fourth child began production sometime between 3;1 and 3;11 (we were not able to observe the child during this period). These ages are within the range for the onset of complex sentences in children learning conventional languages, both spoken (Brown 1973) and signed (Hoffmeister 1978).

Thus, the deaf children in our studies follow the same pattern with respect to early syntactic development as children learning languages from conventional language models. They first experience a one-word period during which they are limited to producing one gesture at a time. They then begin to combine those gestures into two-word sentences characterized by simple structural properties. Finally, they begin to produce longer sentences which convey two or more propositions.

MORPHOLOGY IN THE GESTURES OF DEAF CHILDREN OF HEARING PARENTS

6.1. DERIVATIONAL MORPHOLOGY. At this point in our studies, we have completed the investigation of morphological structure in the gestures of only one deaf child in our sample. (We do, however, have extensive preliminary evidence from two other children suggesting that the gesture systems of these children are also characterized by morphological structure; data from the remaining seven children in our sample have not yet been coded for morphological structure.) We first analyzed the child's characterizing gestures that were most transparent, i.e. the gestures whose form mirrored either the action or an attribute of the intended referent (see §4.2).

We found that the corpus of transparent characterizing gestures that the child produced over a two-year period (from age 2;10 to 4;10) could be characterized as a system of handshape and motion morphemes (Goldin-Meadow & Mylander 1984b, 1990a). We began by coding handshapes and motions continuously along the dimensions typically used to code signs in ASL without establishing a priori either discrete categories or boundaries (e.g., we wrote down the distance between the fingers and thumb of a particular handshape as accurately as possible and did not try to force that handshape into a limited set of thumb-finger distances). We found that the child used only a restricted number of values on each of the dimensions we coded; in fact, 5 handshape and 9 motion forms accounted for 99% of the forms the child produced.

We next asked whether these forms mapped in any systematic way onto categories of meanings. We listed all of the referents that the child represented

with a particular form during the taping session at age 3;11, and determined whether those referents shared a common attribute or set of attributes. If they did, we took that common core to be the meaning of the particular form and used the resulting form/meaning pairing to code the videotapes of the remaining sessions. For example, the Fist handshape form was found to be associated with the meaning 'handle a small, long object'; and the Short Arc motion form was found to be associated with the meaning 'reposition'. We found that 95% of the handshapes and 90% of the motions that the child produced could be classified into the form/meaning pairings established on the basis of the data from age 3;11.

Finally, we found that most of the child's handshape morphemes occurred in combination with more than one motion morpheme, and vice versa. Table 1 presents examples of the Fist handshape combined with three different motions—Short Arc, Arc To and Fro, and Circular—as well as examples of the Short Arc motion combined with three different handshapes—Fist, O-hand, and C-hand. As the table illustrates, the meaning of each gesture is predictable from the meaning of its handshape component and its motion component. For example, the Fist handshape (meaning 'handle a small, long object') combined with a Short Arc motion (meaning 'reposition') formed a gesture which meant 'reposition a small, long object by hand' (e.g., scoop a spoon at mouth). Note that all the motions in the gestures presented in Table 1 represent transitive actions, with the handshapes of these gestures representing the hand of the actor as it is shaped around the patient. These handshape morphemes are comparable to Handle classifiers in ASL, which combine with motions to convey transitive actions (McDonald 1982, Schick 1987).

As in ASL, various handshapes were used not only to represent the handgrip

MOTIONS	HANDSHAPES		
	FIST-HAND (handle a small, long object)	O-HAND (handle a small object of any length)	C-HAND (handle a large object of any length)
SHORT ARC MOTION (reposition)	Reposition a small, long object by hand (e.g. scoop utensil)	Reposition a small, object of any length by hand (e.g. take out bubble wand)	Reposition a large object of any length by hand (e.g. pick up bubble jar)
ARC TO & FRO MOTION (move to & fro)	Move a small, long object to & fro by hand (e.g. wave balloon string back & forth)	Move a small object of any length to & fro by hand (e.g. move crayon back & forth)	Move a large object of any length to & fro by hand (e.g. shake salt shaker up & down)
CIRCULAR MOTION (move in a circle)	Move a small, long object in a circle by hand (e.g. wave flag pole in circle)	Move a small object of any length in a circle by hand (e.g. turn crank)	Move a large object of any length in a circle by hand (e.g. twist jar lid)

TABLE 1. Examples of hand and motion morphemes in the deaf child's gestures. (Note: Circular motions included those made by rotating the wrist, the elbow, and/or the shoulder.)

around objects of varying sizes and shapes, but also to represent the objects themselves. For example, in addition to using the C-hand to mean 'handle a large object of any length' (cf. Table 1), the child also used the C-hand to mean 'a curved object'.⁸ These object handshape components similarly combined with motion components to create paradigms of meanings. For example, the C-hand, when combined with a Linear motion (meaning 'change location'),⁹ formed a gesture which meant 'a curved object changes location' (e.g., a toy turtle moves forward); and, when combined with an Open and Close motion (meaning 'open and/or close'), it formed a gesture which meant 'a curved object opens and/or closes' (e.g., a bubble expands). As these examples suggest, the object handshapes were typically combined with motions representing intransitive actions, with the handshape representing the size, shape, or semantic class of the actor. These object handshapes are comparable to Semantic-Class and Size-and-Shape classifiers in ASL, which combine with motions to create intransitive verbs of motion (T. Supalla 1982, Schick 1987).

The child in our morphological study at times also produced his object handshapes with motions representing transitive predicates. In these gestures the handshape represented the size, shape, or semantic class of the patient—omitting any representation of the actor entirely. For example, to represent placing a toy cowboy on a horse, the child produced a C-hand with his fingers pointed downward (meaning 'a curved object'), combined with a Short Arc motion (meaning 'reposition'), thereby focusing attention on the curved legs of the cowboy as they are placed around the horse. Gestures of this sort are comparable to Size-and-Shape classifiers in ASL, which combine with motions typically to represent instruments of transitive actions (Schick 1987).

The morphemes in the deaf child's gestures were thus organized into a framework or system of contrasts. When he generated a gesture to refer to a particular object or action, the form of that gesture was determined not only by the properties of the referent object or action, but also by how that gesture fit with the other gestures in the lexicon. The child's gestures therefore appeared to reflect a morphological system, albeit a simple one, akin to the system that characterizes the productive lexicon in ASL.

We also analyzed the less transparent gestures that he produced and found that these gestures could not be broken up into morphemic parts, and thus appeared to be unanalyzed wholes in his system. For example, his 'give' gesture

⁸ Thus, the children have two techniques for representing objects: they can incorporate a handshape which stands for the object into the gesture itself (a morphological device), or they can produce a deictic point at the object, or a similar object, along with the gesture (a syntactic device). In the analyses presented above, we relied exclusively on deictic gestures in determining the children's object lexicons (§4.1), their predicate frames (§5.1), and their ordering and production-probability regularities (§5.2). In our future work we hope to describe the relationship between these two techniques for representing objects, and to determine whether that relationship is a systematic one.

⁹ The Linear motion was used to represent change of location from one place to another (e.g. moving a hammer from the floor to the table, or a duck moving from place 1 to place 2) and is distinct from the Short Arc motion, which was used to represent repositioning in place (e.g. swinging a hammer in place, or a duck flipping over in place).

consisted of a Palm handshape held in place (typically with the palm up). In his productive gestures, the Palm handshape meant 'handle a flat surface'; however, the 'give' gesture was used to represent the transfer not only of flat objects but also of round, angular, thin, curved, etc., objects. As a second example, the child's 'break' gesture consisted of two Fist handshapes arced away from each other. In his productive gestures, the Fist handshape meant 'handle a small, long object'; however, the 'break' gesture was used for a wide variety of objects of all shapes and sizes. Thus, this deaf child appeared to display a set of gestures which functioned as do the lexical items in ASL whose stems are unanalyzable and monomorphemic, that is, the so-called 'frozen' lexicon of ASL (cf. Kegl 1985, Newport 1981, T. Supalla 1982).

6.2. INFLECTIONAL MORPHOLOGY. Analyses of the deaf child's gestures suggest that the system also exhibits inflectional morphology (Goldin-Meadow et al. 1990). Conventional sign languages such as ASL have inflectional systems in which spatial devices are used to modify verbs to agree with their noun arguments (e.g., the sign GIVE is moved from the signer to the addressee to mean 'I give to you', but from the addressee to the signer to mean 'You give to me'; Fischer & Gough 1978, Padden 1983). The deaf child in our study could vary the placement of his characterizing gestures (all of them, both the more and the less transparent ones), producing gestures either in neutral space (e.g. a 'twist' gesture performed at chest level) or oriented toward particular objects in the room (e.g. a 'twist' gesture produced near a jar). In the latter case the placement of the gesture served to identify an entity playing a particular thematic role in the predicate represented by the gesture and, as such, served to modify the predicate to agree with one of its arguments.¹⁰ As an example, for transitive predicates the characterizing gesture was typically displaced toward the object playing the patient role—the jar in the above example—thereby marking the jar as the patient of the predicate. In contrast, for intransitive predicates the characterizing gesture was typically displaced toward the object playing the recipient role; for example, the child moved his 'go' gesture toward the open end of a car-trailer to indicate that cars go into the trailer, thereby marking the trailer as the recipient of the predicate. Gestures were very rarely displaced toward the actor of either transitive or intransitive predicates.

As in ASL (cf. Hoffmeister 1978), it was not necessary that an object be in the room for the deaf child in our study to mark that object morphologically via displacement. He could produce his gestures near an object that was similar to the object he wished to refer to, e.g. a 'twist' gesture produced near an

¹⁰ Note that the children have a number of ways of indicating objects that play different thematic roles; for example, the children can displace the gesture for the predicate toward an object playing a particular role (e.g., they can displace the gesture 'eat' toward the patient, 'grape'), or they can produce a deictic gesture for the patient before the gesture for the predicate (e.g., they can produce a point at the grape before the gesture 'eat'). Although these techniques serve the same function, we consider the displacement technique to be morphological because it deals with variations within a single gesture, while the ordering technique is syntactic because it deals with the relationship between gestures. Our future work will explore how these different marking devices work in relation to one another.

empty jar of bubbles to indicate that he wanted the full jar of bubbles in the kitchen twisted open. Or, if the object the child wanted to indicate were animate, the child could indicate the object by producing his gestures on his own body, e.g. a 'twist' gesture produced on the side of his body to indicate that he wanted the experimenter to twist a key on the side of a Mickey Mouse toy. Note that, in this example, the child is representing one individual with his hand (the experimenter) and a different individual with his body (Mickey Mouse): thus, as is frequently the case in ASL, the child appears to be using his body as a stage for his own gestures.

In a developmental analysis, we found that he first began to displace his gestures toward objects that were similar to his intended-but-absent referents between the ages of 3;3 and 3;5—the age at which this same child began producing points at objects in the room to refer to objects that were not in the room (see §4.1.). Thus, this child's morphological marking system began to be freed from the here-and-now situation at about the same moment in development as his system of pointing gestures.

6.3. DEVELOPMENTAL PATTERN: MORPHOLOGICAL REORGANIZATION. The developmental course of the deaf child's gestures was comparable to the development of words or signs in children acquiring conventional languages (Mylander & Goldin-Meadow 1990). When first generating gestures, he created each gesture to map onto an individual event; that is, he used a particular handshape/motion combination, for example a C-hand combined with a Circular motion, to refer only to opening a jar and to no other actions or objects. This stage is reminiscent of the period during which children acquiring conventional languages treat their words or signs as unanalyzed wholes (MacWhinney 1978, Newport 1984, Peters 1983). Later in development, between the ages of 3;3 and 3;5, this deaf child began to use a single gesture to refer to a class of events, with components of gesture form mapping onto components of gesture meaning, rather than the whole gesture form mapping onto a global, particular event. For example, he used the C-hand combined with a Circular motion to refer to opening a jar, rotating a wide knob, moving a train in a circle, etc.; that is, he used the C-hand in this and in other gestures to refer to a class of objects (objects with large diameters that can be grasped by hand), and he used the Circular motion in this and in other gestures to refer to a class of actions (rotating or moving objects around a center point). This latter stage is comparable to the period when children acquiring conventional languages begin to analyze the words they have learned as wholes and separate these words into meaningful components (Bowerman 1982, MacWhinney 1978, Newport 1984).

The reorganization of the child's lexicon from an unorganized collection of gestures to a system of contrasting gestures may reflect a larger reorganization taking place across several parts of his linguistic system. For example, he began to analyze his gestures into component morphemes sometime between the age of 3;3 and 3;5—the age at which he began to refer (either via the placement of his characterizing gestures [see §6.2] or via his pointing gestures [see §4.1]) to objects that were not present in the room. Thus, the child began to syste-

matize his lexicon at the same time as he began to use his gestures in an increasingly symbolic fashion. The impetus for a reorganization of this sort might be the child's maturational state (i.e. the fact that he had reached a certain age), or perhaps the state of the gesture system itself (i.e. the fact that the system had become sufficiently cumbersome to require reorganization). Developmental analyses of the gesture systems of the remaining deaf children in our sample may help to pull apart these possibilities.

THE ROLE OF PARENTAL GESTURES IN GUIDING THE DEAF CHILD'S SYSTEM

7. The deaf children in our studies were found to elaborate gestural communication systems characterized by a lexicon, a simple syntax, and a simple morphology without the benefit of a conventional language model. It is possible, however, that the children's hearing parents spontaneously generated their own structured gesture systems which their children saw and learned. The parents—not the children—would then be responsible for the emergence of structure in the children's gestures.

The hearing mothers of the deaf children in our studies all produced gestures as they spoke to their children.¹¹ Indeed, five of the six mothers whose gestures we analyzed in detail produced single gestures (as opposed to gesture strings) more often than their children. Moreover, the mothers produced both pointing and characterizing gestures, and they produced them in approximately the same proportions as their children. However, the mothers produced fewer different types of characterizing gestures than their children, and their lexicons of characterizing gestures were different from their children's, overlapping no more than 33% and as little as 9% (Goldin-Meadow & Mylander 1984a:78–79).

Despite the fact that the mothers were prolific producers of single gestures, they were not prolific producers of gesture strings: five of the six mothers produced gesture strings less often than their children (Goldin-Meadow & Mylander 1984a:80). In addition, the mothers' gesture strings did not show the same structural regularities as their children's (Goldin-Meadow & Mylander 1983, 1984a:81–89). The mothers showed no reliable gesture-order patterns in their strings. Moreover, the production-probability patterns in the mothers' gesture strings differed from the production-probability patterns in the children's strings. Finally, the mothers began conveying two propositions in their gesture strings later in the study than their children did, and produced proportionately fewer sentences with conjoined propositions than their children did.

With respect to morphology, the mother of the single deaf child whose gestures we have analyzed for morphological structure was found to produce the same 5 handshape and 9 motion forms as her child. In terms of form-meaning mapping, however, only 50% of the mother's handshapes and 51% of her motions could be described by the system developed to describe the child's form-meaning pairings for handshapes and motions; in contrast, recall that 95% of

¹¹ We studied the mothers' gestures rather than the fathers' gestures because in each instance the mother was the primary caretaker.

the child's handshapes and 90% of his motions could be described by this system. Moreover, the fit between the child's form-meaning mapping system and his mother's did not improve over the two-year period during which the child was observed. In addition, the child appeared to have generalized beyond his mother's gestures in two respects: (1) The child produced almost all of the different types of handshape/motion combinations that his mother produced (20 of his mother's 25), but, in addition, he produced another 34 combinations that were not found in his mother's repertoire. In order to go beyond his mother's gestures as he did, the child must have isolated the handshape and motion dimensions and used them as a basis for generating his novel combinations. (2) The mother used her gestures to refer to individual events (e.g., she used the C-hand combined with a Circular motion only to refer to opening a jar and to no other types of actions or objects), while the child used his to refer to classes of related events (Goldin-Meadow & Mylander 1990b). Thus, at most, the mother's gestures may have served as a source for the handshape and motion components in the deaf child's gestures. However, it is important to note that, in order to utilize that source, the child would have had to search through considerable noise in order to arrive at the components. Moreover, he appeared to treat whatever structure he might have found in his mother's gestures as a starting point, using it to generalize to novel combinations and to novel referential uses.

With regard to the input issue in general, it is important to note that we are not claiming that deaf children develop their gesture systems in a vacuum. It is clear that the children receive input from their surroundings, which they undoubtedly put to good use. The crucial question, however, is this: how close is the mapping between this input and the child's output? We have looked for isomorphic patterns between the mother's gestures and the child's gestures on the assumption that the child might have been inclined to copy a model that was easily accessible. We found that the gesture systems developed by the deaf children in our studies had some obvious similarities to the gestures produced by their hearing mothers: both the children and their mothers produced pointing and characterizing gestures which they used to express the action and attribute relations typical of early mother-child conversations. However, the children consistently surpassed their mothers by organizing these gestural elements into productive systems with patterns on at least two linguistic levels—the level of the sentence and the level of the word. All of the deaf children regularly combined the gestural elements into linear strings characterized by a syntactic structure, albeit a simple one. The one child studied so far analyzed the gestural elements into component parts characterized by a productive morphologic structure. Thus, our deaf children had indeed gone beyond their input, contributing linearization and componentialization to the gestures they received as input from their hearing mothers.¹²

¹² Of course, it is possible that the deaf child made use of other cues in the environment (such as speech) in conjunction with the mother's gesture model in order to make this model more functional. But note that this hypothesis necessitates attributing to the child a great deal of creative interpretation of the input. The child must take a 'mixed-mode' message (in which one signal—

SUMMARY OF THE CHILD'S CONTRIBUTIONS TO LANGUAGE LEARNING

8. In this section we summarize the inferences we have drawn about the biases children bring to the task of communicating. We maintain that those properties of language which can be developed by deaf children without a language model are 'resilient' (in the sense that their development is insensitive to wide variation in input conditions) and are therefore primarily contributed by the child. We will discuss the conclusions from our deaf children's data in relation to findings from other studies of children's language-making capacity, and consider the children's contributions in the context both of the semantic organization and of the structural organization of their communication systems.

8.1.1. SEMANTIC ORGANIZATION: ORGANIZING PREDICATE FRAMES. The deaf children's gesture systems were organized around different predicate types, each associated with a particular combination and number of arguments. This finding supports the hypothesis that children come to the language-learning situation equipped with a bias to organize their language around a predicate calculus. Indeed, on the basis of his review of the crosslinguistic literature Slobin (1985:1192) suggests that children come equipped with 'definitions of "proposition types" in terms of some sort of presumably innate predicate calculus'. Similarly, in his account of language learning Pinker (1984:333) relies heavily on the child's giving the correct thematic analysis to verbs, and goes so far as to suggest that 'the core of the thematic relations system does not require a special acquisition mechanism dedicated to inducing it from the input.' Finally, Gleitman (1986:22) has suggested that children come to the language-learning situation equipped with predicate types of the sort we have found in the deaf children's gesture systems, and that they use those predicate types as a starting place for extracting and differentiating verb meanings in the languages they are learning.

8.1.2. FOCUSING ON THE PATIENT. The deaf children in our study appeared to organize their gestures in such a way as to highlight the patient role. They exhibited a focus on the patient in the organization both of their pointing gestures and of their characterizing gestures. On a syntactic level, all ten children were more likely to produce pointing gestures for objects playing the patient role than for objects playing the actor role in transitive actions; this particular production-probability pattern tends to result in two-gesture sentences that preserve the unity of the predicate, i.e. patient+act sentences rather than actor+act sentences. Moreover, the deaf children tended to treat the intransitive actor like the patient rather than like the actor of transitive actions, suggesting a focus on the affectee properties rather than the effector properties of the intransitive actor (see §5.2). On a morphological level, all three of the

speech—is very severely degraded) and transform it into a structured single-mode output. If the child were indeed able to construct gesture patterns out of cues found in the mother's speech and gesture taken together, it merely reinforces our point: since clues to structure were not at all obvious in the child's environment, the child was likely to have been predisposed to search for those kinds of structures in the first place.

deaf children whose data we have examined for morphological structure displaced their transitive characterizing gestures (when they marked those gestures) toward an object playing the patient role but rarely toward an object playing the actor role.

This patient-focus is reminiscent of the focus on transitivity and the results of actions that Slobin 1985 posits as part of the starting semantic space that children bring to the language-learning situation. In addition, children acquiring conventional language have been found to focus on the patient even if it means violating their input. For example, Ochs 1982 has shown that children acquiring Samoan adopt AVO or VOA word order for transitive sentences rather than the canonical adult VAO order. Thus, the Samoan children, like our deaf children, tended to preserve the unity of the predicate (i.e., VO appears as a unit) and to treat the intransitive actor like the patient (i.e., the position after the V, which is filled by S in the intransitive sentences of both adults and children, is filled by O in transitive sentences). As a second example, children learning English tend as a rule to omit words for the actors of their sentences (preserving the unity of the predicate; cf. Bloom 1970) but to omit words for the actors of their intransitive sentences less often than words for the actors of their transitive sentences (Goldin-Meadow 1979:176).¹³ In fact, for young children learning English, actors tend to appear in intransitive sentences about as often as patients appear in transitive sentences, a tendency which (as in our deaf children) highlights the affectee properties of the intransitive actor (Goldin-Meadow 1979:176).

8.2.1. STRUCTURAL ORGANIZATION: MECHANISMS FOR DISTINGUISHING THEMATIC ROLES. The deaf children used a variety of devices that distinguished among different thematic roles (e.g. patient and actor). They varied the positions of the gestures in their two-gesture sentences according to the thematic roles of the objects represented by those gestures. They varied the probability with which they produced gestures for objects according to the thematic role played by that object. They varied the placement of their characterizing gestures, displacing gestures near objects playing particular thematic roles. The findings in our deaf children support the notions of Pinker (1984:40), who argues that children come to the language-learning situation prepared to consider semantic notions such as agent and patient as linguistically relevant, and that they are prepared to use those semantic notions initially to identify grammatical entities such as subject and object in their input.

In terms of the particular devices used to distinguish among thematic elements, our data support Slobin's suggestion (1985:1192) that the child comes to the language-learning situation with a disposition to notice and store sequential orders of classes of elements. Moreover, although perhaps forced to

¹³ Hyams 1986 argues that the tendency to omit words for actors at the beginning stages of language acquisition in English-learning children (and in Italian- and German-learning children as well) reflects the initial setting of the pro-drop parameter allowing subjects to be optional. Note, however, that the pro-drop explanation does not easily account for English-learning children's tendency to omit words for transitive actors more often than words for intransitive actors.

omit words from their sentences for processing reasons, young hearing children appear to omit words for particular classes of elements rather than omitting words on a random basis (cf. Bloom 1970, Hyams 1986). Finally, deaf children learning conventional sign languages have been found to generate spatial devices to mark their signs to agree with particular classes of elements, even if their input language does not provide evidence for such devices (Gee & Goodhart 1985, Goodhart 1984, Livingston 1983, S. Supalla 1990, Suty & Friel-Patti 1982).

8.2.2. INTRODUCING RECURSION. The deaf children in our study generated novel complex sentences (containing at least two propositions) from combinations of simple one-proposition sentences, thereby exhibiting the property of recursion in their gesture systems. These data are consistent with the observations of Newport et al. (1977), who found that the number of verbs that hearing children used in a sentence (a measure which corresponds approximately to the number of propositions in a sentence) was an environment-insensitive property of language. That is, maternal input did not affect the rate at which children developed this property in their language. These data suggest that child-centered factors (rather than environment-centered factors) may influence the development of the ability to conjoin propositions within a sentence.

8.2.3. CREATING PARADIGMS. Completed data from one deaf child and preliminary data from two others in our sample suggest that the children organized their gestures using paradigms or matrices which served as the basis for their morphological system. According to Slobin (1985:1213), the capacity to create paradigms is central to the child's language-making capacity. Moreover, paradigm construction is an important component of Pinker's (1984) account of language learning. In addition, Pinker (1984:180) suggests that the child first creates word-specific miniparadigms and only later abstracts the patterns contained within them to create general paradigms—a developmental pattern reminiscent of our deaf child's morphological development.

GESTURE AS AN ADJUNCT TO SPEECH VS. GESTURE AS A PRIMARY COMMUNICATION SYSTEM

9.1. GESTURE DEVELOPMENT IN CHILDREN WITH LINGUISTIC INPUT. Hearing children in the early stages of language acquisition exploit the manual modality for purposes of communication. In fact, prelinguistic hearing children use pointing gestures several months before they begin to speak (Bates 1976) and continue to use gesture to support their verbal communications even after they learn to speak (Bates et al. 1979, Carter 1975, Goldin-Meadow & Morford 1985, Greenfield & Smith 1976).

However, it is important to note that, unlike the deaf children in our studies, hearing children do not elaborate their spontaneous gestures into linguistic systems. Not surprisingly, speech comes to dominate over gesture in the hearing child, and this domination typically occurs before the child's gestures become complex. For example, hearing children rarely produce their pointing gestures in combination with other gestures, even other points (Goldin-Meadow

& Morford 1985, Goldin-Meadow & Mylander 1984a:55, Masur 1983), and they do not produce strings of characterizing gestures (Petitto 1988, Volterra 1981).

Moreover, young hearing children produce very few motor acts that would meet our criteria for characterizing gestures (i.e. motor acts that do not involve direct manipulation of objects and that are used for communication rather than symbolic play; cf. Goldin-Meadow & Mylander 1984a:54, Petitto 1988). Even when hearing children produce the same characterizing gestures as the deaf children in our studies, they use those gestures differently. For example, one of the most common characterizing gestures that hearing children produce is the 'give' gesture—open palm extended as though to receive an object. Hearing children use this gesture almost exclusively to request objects for themselves (Petitto 1988), while the deaf children in our studies used the 'give' gesture across a variety of semantic situations to request the transfer of objects to other people and locations as well as to themselves. In general, hearing children tend to use their characterizing gestures as names for particular objects (often non-transparent names developed in the context of interactive routines with parents, e.g. index fingers rubbed together to refer to a spider; Acredolo & Goodwyn 1985, 1988), and their gestures therefore do not appear to have the internal handshape and motion structure characteristic of the deaf children's gestures. Unlike the deaf children's gestures, the gestures produced by hearing children do not seem to be organized in relation to one another and so do not form a system of contrasts.

9.2. GESTURE WITH SPEECH VS. GESTURE WITHOUT SPEECH. McNeill (1990:Ch. 6) has described the gestures that characteristically accompany speech in hearing children (and hearing adults as well) as less clear, less disciplined, less reproducible, and less schematic than the gestures used by the deaf children in our studies. The gestures that accompany speech in hearing individuals differ from the deaf children's gestures in that they do not stand on their own, but rather form an integrated system with the speech they accompany (McNeill 1985; see also Church & Goldin-Meadow 1986, Perry et al. 1988). Unlike the gestures produced by the deaf children in our studies, which tend to be linear and segmented, the gestures that accompany speech in hearing individuals are 'GLOBAL in that the symbol depicts meaning as a whole (noncompositionally) and SYNTHETIC in that the symbol combines into one symbol meanings that in speech are divided into segments' (McNeill 1987:18).

The fact that gesture forms an integrated system with the speech it accompanies may explain why the hearing mothers of our deaf subjects produced gestures which were organized so differently from their deaf children's gestures. Since almost all of the mothers' gestures were accompanied by speech, it is likely that the mothers' gestures (like those of all hearing speakers) were influenced by the spoken utterances with which they occurred. Many of the mothers' gestures that appear unstructured and uninterpretable when analyzed with the techniques developed to analyze our deaf children's gestures—all primary communication systems—may in fact be quite structured and meaningful when analyzed in relation to the speech they accompany, i.e. with a

system developed to code gesture as an adjunct to speech (cf. McNeill 1990). It goes without saying, however, that the structure of this combined speech/gesture communication is lost on our deaf children, for whom speech input is unavailable.

The fact that the gestures of hearing individuals do not, in general, exhibit inter-gesture and intra-gesture structure suggests that communication in the manual modality does not inevitably result in structure at the sentence and word levels. While gesture used as a primary communication system (as in our deaf subjects) appears to assume language-like structure, gesture used as an adjunct to speech does not necessarily do so.

We have previously referred to the language-like properties found in the deaf children's gestures as 'resilient' (Goldin-Meadow 1982)—properties that appear in children's communication despite extensive variation of the learning conditions (such as no exposure to an established language). Properties that show up under such extreme conditions are evidently among the most basic and indispensable for a structured system of human communication, and they should spontaneously appear in any deliberate communication of meaning (cf. McNeill 1990:Ch. 6). That these same resilient properties are not systematically used in the spontaneous gestures accompanying the speech of both hearing children and hearing adults underscores (and continues to clarify by contrast) the 'language-like' nature of the deaf children's gestures.

CONCLUSION

10. We have explored the child's contribution to the language-acquisition process by investigating a situation in which children have gone beyond the linguistic input they have experienced. We have shown that deaf children who are unable to use conventional spoken language models provided by their hearing parents and who are not exposed to conventional sign language models use gesture to communicate. These gestures exhibit simple structural properties at three levels: (1) LEXICON, consisting of pointing gestures which refer to objects either in the immediate environment or absent from the here-and-now, and characterizing gestures which refer to actions and attributes; (2) SYNTAX, consisting of predicate structure, ordering and production-probability rules, and recursion; and (3) MORPHOLOGY, consisting of both derivational and inflectional morphology.

Although the deaf children in our studies did not receive input from a conventional sign-language model, the children were clearly exposed to the spontaneous gestures that their hearing parents used as they spoke to their children. At the lexical level, the children's gestures were found to share properties with the spontaneous gestures produced by their mothers. However, the children surpassed their mothers in taking these gestures and organizing them into a productive linguistic system, combining them into structured linear strings characterized by a simple syntax, and analyzing them into hand and motion components characterized by a simple morphology. These properties of linearization and componentialization appear to distinguish gesture used as a pri-

mary communication system by a deaf child from gesture used as an adjunct to speech by hearing children and hearing adults.

The phenomena of gesture generation in deaf children of hearing parents suggests that children come to language predisposed to analyze and combine the words, signs, or gestures they use to communicate. Thus, with or without an established language as a guide, children appear to be 'ready' to seek structure at least at word and sentence levels when developing systems for communication.

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[Received 18 August 1988;
revision received 11 December 1989;
accepted 5 February 1990.]