ODYSSEY REQUEST

CHILDREN'S LANGUAGE

Volume 5

edited by

Keith E. Nelson
The Pennsylvania State University

LAWRENCE ERLBAUM ASSOCIATES, PUBLISHERS
1985 Hillsdale, New Jersey London

Country Stars is part of William Meredith's set of poems published under the title *The Cheer* by Alfred A. Knopf in New York (1980).

Lawrence Erlbaum Associates, Inc., Publishers
365 Broadway
Hillsdale, New Jersey 07642

ISSN 0163-2809

ISBN 0-89859-346-8

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

Contents

7 Language Development Under Atypical Learning Conditions: Replication and Implications of a Study of Deaf Children of Hearing Parents

Susan Goldin-Meadow
University of Chicago

We have shown that deaf children, whose severe hearing losses have prevented them from making use of the oral language input that surrounds them and whose hearing parents (having chosen to educate their children under the oral method) have not yet exposed them to conventional manual language input, can develop spontaneous gestural communication systems which are structured as natural child language systems are (Feldman, Goldin-Meadow, & Gleitman, 1978; Goldin-Meadow, 1979, 1982; Goldin-Meadow & Feldman, 1977). Thus, a child deprived of the rich linguistic input children typically receive can nevertheless develop a communication system which is language-like in many structural respects. This phenomenon suggests that the child has strong biases to communicate in language-like ways.

The phenomenon of gesture creation in deaf children has powerful implications for the nature–nurture question with respect to language acquisition. Accordingly, it would be important if this phenomenon were shown to be a robust one, not tied to any one population in any one locale, nor an artifact of any one method of data analysis. We have, up until this point, studied the phenomenon in six deaf children of hearing parents, ranging in age from 1;5 to 4;1 at the first interview, all living in the Philadelphia area. I present data in the next three sections that replicate this phenomenon on a second sample of four deaf children of hearing parents, ranging in age from 1;4 to 3;1 at the first interview and residing in a different region of the United States (the Chicago area). Further, I address the methodological and theoretical difficulties that have been raised in conjunction with this work, in particular, with our notions of underlying structure. Finally, I consider the implications of this phenomenon for developmental theories of language acquisition.

REPLICATION

Purpose and Rationale

As in our previous work, this replication study focuses on three primary questions. I first ask whether the deaf children in the second sample use gestures to communicate in the same way as our original subjects did. I then proceed to determine whether each child uses those gestures in a structured fashion; that is, can consistent patterns of production be found *within* each child's set of gestures? Finally, I ask whether those structured regularities are language-like; that is, are they regularities that can be found in natural human languages?

It is, of course, unlikely in the extreme that any one of our deaf subjects can develop a gesture system as complex as a naturally occurring language spoken by adults. After all, young children, even when exposed to language models, do not develop languages as complex as adult languages during their early stages. Consequently, the heuristic I have adopted in this study is to compare the gestures developed by my deaf subjects to naturally occurring *child* languages. I use the tools researchers have developed to study natural child languages to determine whether my deaf subjects' gestures are structured, and I use descriptions of the structural properties of natural child language as the framework within which to evaluate whether my deaf subjects' gestures are language-like.

It should be noted, however, that researchers within the field of child language are not in total agreement over which particular classification system should be used to describe the language of young children (see, e.g., Bowerman, 1978, for discussion). Here I adopt one widely used technique to describe my deaf children's gestures—the method of rich interpretation originally proposed by Bloom (1970) (see the sections on Underlying Structure for further discussion). I first show that this technique, with some additional assumptions, can be used to describe the deaf children's gestures. In the section on Coding Categories, I detail the assumptions and criteria I have used in applying the method of rich interpretation to my deaf subjects' gestures, showing where my procedures follow those standardly used in child language descriptions and where my procedures necessarily differ as a result of the idiosyncratic nature of the deaf child's gestures. I then show that when this descriptive system is applied to the deaf children's gestures, each child's gestures appear to be structured as were the gestures of our original deaf subjects (see the section on The Deaf Child's Communication System). We have shown elsewhere (see Goldin-Meadow, 1979; Goldin-Meadow & Mylander, 1984) that the *types* of structures (not necessarily the particular structures themselves) found in all of the deaf children's gestures can be found in the hearing child's early word sentences as well.

In sum, my goal in this study is to show that the gesture systems developed by both my old and new deaf subjects *without* the benefit of a conventional language model, when described using the tools of the field of child language, contain the structural properties of the language systems developed by young children who *have been* exposed to conventional language models.

Methods and Procedures

Subjects

The four children in this study, two girls and two boys, ranged in age from 1;4 to 3;1 at the time of the first interview and 3;8 to 4;2 at the time of the final interview (see Table 7.1, which also presents comparable information in summary form on the six Philadelphia subjects;[1] the names of all subjects have been changed in this report). Each of the four Chicago children came from white, middle-class families. At the time of these observations, Marvin had no siblings, Karen one younger hearing sibling, Abe one older hearing sibling, and Mildred three older hearing siblings. All had two parents living in the home, with mother as primary caregiver.

Each child was congenitally deaf with no other known cognitive or physical disabilities. Each had a severe to profound (greater than 90 dB) hearing loss and, even when wearing hearing aids (which the children wore continuously at school and often at home), was unable to acquire speech naturally.

All four children were being educated by the oral method of deaf education, a method which advocates early and intense sound training for the deaf child and which discourages the use of conventional sign language. Mildred, Karen, and Marvin all attended one oral preschool for the deaf in the Chicago area, and Abe attended a second oral preschool. When first observed, each of the children was receiving private sound sensitivity lessons 1 or 2 days a week and was not yet enrolled in daily group classes. Part way through the study, the children graduated first to half-day and then to full-day group sessions. At the time of these interviews, the children had made little progress in acquiring spoken English.

In addition, none of the four children was exposed to conventional sign language (e.g., Signed English or American Sign Language). Consistent with the oral education philosophy, sign language was not used in either of the oral schools these children attended. Moreover, neither the children's hearing parents nor their hearing siblings knew sign language. Thus, these children, who at the time of the study had made little use of oral linguistic input, were also not exposed to conventional manual linguistic input.

It is, of course, possible that, in an effort to communicate, the hearing caregivers of these deaf children spontaneously generated a structured ges-

[1]See Goldin-Meadow (1979) for further details on the six Philadelphia subjects.

TABLE 7.1
Summary Description of Gesture Samples

Chicago Subjects					
Child	*Session*	*Age (yrs;mos)*	*Mean Length of Gesture Sequence (MLG)*	*Longest Gesture Sequence Produced (Upper Bound)*	*Number of Gesture Sequences Per Hour (Rate)*
Mildred	I	1;4	1.07	2	52.5
	II	1;6	1.12	4	72.4
	III	1;10	1.14	3	24.7
	IV	1;11	1.31	3	47.3
	V	2;2	1.13	3	40.6
	VI	2;4	1.11	2	50.6
	VII	2;8	1.07	2	83.6
	VIII	2;11	1.25	5	72.4
	IX	2;12	1.17	4	40.6
	X	3;2	1.15	3	49.1
	XI	3;5	1.25	4	102.4
	XII	3;8	1.31	5	94.5
Abe	I	2;3	1.00	1	24.6
	II	2;5	1.19	2	60.0
	III	2;9	1.17	2	54.6
	IV	2;10	1.17	4	111.6
	V	3;0	1.19	6	100.2
	VI	3;4	1.22	4	109.2
	VII	3;5	1.28	3	51.0
	VIII	3;7	1.17	3	120.0
	IX	3;9	1.30	8	158.4
Marvin	I	2;11	1.33	3	91.8
	II	3;1	1.35	3	85.5
	III	3;4	1.26	3	87.3
	IV	3;7	1.37	8	156.4
	V	3;9	1.22	3	180.0
	VI	4;2	1.41	7	187.5
Karen	I	3;1	1.23	3	67.5
	II	3;4	1.08	3	71.3
	III	3;7	1.29	6	127.5
	IV	3;11	1.38	4	110.6
	V	4;0	1.36	5	140.6
	VI	4;2	1.39	4	133.1

Philadelphia Subjects					
Child	*Number of Sessions*	*Age Range*	*MLG Range*	*Upper Bound Range*	*Rate Per Hour Range*
David	8	2;10-3;10	1.14-1.80	2-9	36.0-384.0
Donald	11	2;5 -4;6½	1.04-1.25	2-4	6.6-198.3
Kathy	9	1;5 -2;8	1.00-1.27	1-6	40.0- 93.0
Dennis	4	2;2 -2;6	1.04-1.21	2-3	50.9-102.0
Chris	3	3;2 -3;6	1.15-1.20	4	92.2-120.9
Tracy	2	4;1 -4;3	1.22-1.30	4-6	119.1-142.1

ture system, which their children then learned, or that the caregivers unconsciously shaped the structure of their children's gestures by patterning their responses to those gestures. Both of these hypotheses have been shown to be false in an analysis of the communications of six hearing mother-deaf child pairs (the four subjects described here and two others from our original Philadelphia sample; see Goldin-Meadow & Mylander, 1983, 1984).

Procedure

Each child was video taped at home during play sessions approximately once every 2 to 4 months (see Table 7.1). The primary caregiver, the mother in every instance, was asked to interact with her child for at least ½ hour of each session. Either the mother then continued to play with the child, or an experimenter or one of the child's siblings played with the child for the remainder of the session. A large bag of toys, books, and puzzles (described in Goldin-Meadow, 1979) served to facilitate interaction. Each session lasted from 1 to 2 hours, depending on the child's attention span.

Each child's video tapes were coded for both vocalizations and gestures. Because the coding system is central to the interpretation of results, I review and justify the coding decisions and criteria in some detail in the next section.

CODING CATEGORIES

How does one begin a description of the deaf child's gesture system? The problem lies, in some sense, in entering the system. After all, there is no established language model toward which the deaf child's system is developing. Consequently, there are no hints from a conventional system that might guide initial descriptions. As a result, 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, how to describe them and assign them meanings).

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

Having established preliminary coding categories, we began to utilize them while transcribing video tapes. We tested the utility of our tentative categories in two ways. We first asked if the coding categories were reliable and established reliability by comparison of judgments between 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 83% and 100% depending on the coding category), confirming category reliability.

The second and more important test of our category definitions was to ask 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 turns out to be coherent, this fact is substantial evidence for the usefulness of the categories themselves. Consider the following example. Suppose we applied the semantic categories *patient* (object acted upon) and *act* to the deaf child's gestures. If we then discover a pattern based on those categories (e.g., a sign-ordering rule following, say, a *patient-act* pattern), a pattern which has both retrospective validity and predictive value, we have some evidence that those particular categories are useful descriptions of the deaf child's system. The very existence of the pattern confirms the utility of the categories, because 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 spoken child language. Although this problem can never be completely avoided, the following assumption allows us to proceed: A coherent description of the deaf child's gestures is more likely to be accurate than is an incoherent description. That is, if a category turns out to "make sense of," or organize, the child's communications (e.g., by forming the basic unit of a pattern), we are then justified in isolating that category as a unit of the system and in attributing that category to the child. In sum, the consistency of the results described here and in our previous work justifies the establishment of the coding categories described herein.

Identifying a Gesture

In attempting to describe the features of the deaf child's gestured communications, the 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 in some sense indicates that the eater has had enough) from those acts whose sole purpose seems to be to communicate (e.g., a "stop-like" movement of the hands produced in order to suggest that another helping is not necessary). Inasmuch as 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), 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 an illuminating discussion of this problem), we have 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 subject makes an attempt 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 his or her partner). Second, the gesture must *not* be a direct motor act on the partner or on some relevant object. As an example, if subjects attempt to twist open a jar, they are not considered to have made a gesture for *jar* or *open*, even if in some sense they, by this act, are trying to communicate to the experimenter to do something (i.e., to help open the jar). But if subjects make a twisting motion in the air, with their eyes first on the experimenter's eyes to establish contact, we consider a communicative gesture to have been made.

Once isolated, the children's gestures were recorded in terms of the three dimensions commonly used to describe signs in American Sign Language (ASL) (see Stokoe, 1960): the shape of the hand, the location of the hands with respect to places on the body or in space, and the movement of the hand or body.

Segmenting Signs and Sentences

After determining how to isolate gestures from the surrounding motor context, we next determined the units appropriate for describing combinations of gestures. We faced two segmentation decisions. First, are there grounds for dividing one long complicated gesture into more than one word-like or *sign* unit? Second, are there grounds for parsing sequences of these sign units into larger organizations? That is, can these signs be said to be concatenated into *sentences*?

Defining a Sign

We employed distributional criteria for sign segmentation whenever possible (cf. Bloomfield, 1933; Harris, 1951). Specifically, a gesture was considered to be composed of two signs if each of those signs occurred separately in other communication contexts. However, distributional criteria alone were insufficient for segmenting signs, primarily because there was no corpus extensive enough for these purposes. Therefore, an intuitive criterion based on the motor organization of the gesture was also used. A sign was defined as a continuous, uninterrupted gestural flow or a single motor unit. This motor flow, though difficult to describe (particularly without an established descriptive system of motor organization), was nevertheless easy to note, especially because of the change or break in the flow of movement preceding and following the sign. For example, a child might produce a twisting movement and then, breaking the twist, point to the table. The twist movement is, in some unformalizable sense, self-contained, as is the pointing movement; these movements, therefore, comprise two units, each of which is called a sign. The results described later in this paper suggest that the segmentation criteria chosen to isolate sign units feed into a coherent structural description of the deaf child's gesture system; that is, the criteria chosen allow us to isolate units that seem to be appropriate for the deaf child's system.

Defining a Sentence

The most obvious determinant of sentence boundaries was timing: If two signs were uninterrupted by an appreciable time interval, they were candidates for being "within a sentence." Conversely, if two signs were interrupted by an appreciable pause, they were likely to belong to separate sentences. However, sequential signs were judged by an additional criterion in order to be considered within or outside of a single sentence: the return of hands to neutral signing space. If present, the relaxation of the hands in front of the body after a gesture or series of gestures was taken to signal the end of a sentence. For example, if a child pointed to a toy and then, without bringing his hands to his chest or lap, pointed to the table, the two pointings were considered within a sentence. The same pointings, interrupted by a relaxation of the hands, would be classified as two isolated signs. This second criterion was chosen initially because "return to neutral position" is recognized to mark sentence boundaries in ASL (see Stokoe, 1960). We have continued to use these criteria for our deaf children's gestures because, using our bootstrap heuristic, when these criteria are employed to define sign sentences, a coherent description of the deaf children's gestures is produced.

Assigning Lexical Meanings to Signs

Our subjects produced three types of signs, which differed in form. *Deictic* signs were typically 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* signs were noted to be stylized pantomimes whose iconic forms varied with the intended meaning of each sign. For example, a fist pounded in the air as someone was hammering or two hands flapping in the presence of a pet bird both were considered characterizing signs. Finally, *marker* signs were typically head or hand gestures (e.g., nods and side-to-side shakes, one finger held in the air signifying *wait*) which tend to be conventional in our culture and which the children used as modulators (e.g., to negate, affirm, doubt).

We next attempted to devise a system to assign lexical meanings to both deictic and characterizing signs. The problems we faced were in many ways comparable to those that arise in assigning meanings to a young hearing child's words. Consider an English-speaking child who utters the sentence *duck walk,* as a toy Donald Duck waddles by. Adult listeners assume that because the child has used two distinct phonological forms, *duck* and *walk,* she intends to convey two different meanings, that is, to talk about two semantic aspects of the event in front of her, the feathered object and the walking action. Specifically, it is assumed that the child's noun *duck* refers to the object and that the verb *walk* refers to the action of that object.

Note that in attributing lexical meanings to the young hearing child, it is assumed that the child's particular lexical meanings for the words *duck* and *walk* coincide with adult meanings for these words. In general, we 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), is bolstered by data from the child's language system taken as a whole. To the extent that children have mastered other aspects of the adult system that are based on the noun-verb distinction (e.g., verb agreement), they can plausibly be said to have mastered the distinction in the instance of lexical meanings.

At this same stage of the lexical meaning assignment procedure for the deaf subjects, we must also make assumptions. However, this time there is no adult language model to guide us. The decision criteria behind the inferential assumptions for the deaf subjects therefore must differ from those for the hearing child. For the deaf child's gesture system, we chose to use sign form as a basis for lexical assignment decisions. We assumed, in general, that deictic signs (e.g., point at the duck) refer to objects, people, and places and that characterizing signs (e.g., walking motions produced by the hands) refer to actions and attributes (see the following discussion). This decision is motivated and justified by a number of lines of argument.

Glossing Deictic Signs

The assumption made in assigning lexical meanings to deictic signs was that the child's pointing sign was, in fact, intended to make reference and that the referent of that deictic sign was a person, place, or thing (and not an action or an attribute). This assumption is motivated as follows. When pointings are included in analyses as nominal lexical items, the deaf children's sign systems look remarkably similar, both semantically and syntactically, to the hearing child's early spoken language. Semantically, the referents of the deaf children's deictic signs can be described in terms of precisely those categories that can be used to describe the referents of the hearing child's nouns (see Feldman et al., 1978). Syntactically, as has been previously shown (Feldman et al., 1978; Goldin-Meadow, 1979) and as is shown later here, deictic signs appear to play the same role in the deaf children's sign sentences as nominals play in the hearing child's spoken sentences. For these reasons, we feel justified in including pointing signs as nominal lexical items in our analyses.

Note that these deictic signs, like pro-forms (e.g., in English, *this* or *there*), effectively allow the child to make reference to any person, place, or thing in the present (remarkably, the deaf child appears to be incapable of taking full advantage of this latitude and instead acquires only as limited a nominal vocabulary as the hearing child at a comparable stage; see Feldman et al., 1978; Goldin-Meadow & Morford, 1984). Further, as with the hearing child's pro-forms, context is essential for the interpretation of the deaf children's deictic signs.

It should be recognized that the relationship between the pointing sign and its referent is, at some level, quite different from the relationship between a word and its referent. The pointing sign, unlike a word, serves to direct a communication partner's gaze toward a particular person, place, or thing; thus, the sign explicitly specifies the location of its referent in a way that a word (even a pro-form) never can. The pointing does not, however, specify what the object is; it merely indicates *where* the object is. That is, the pointing is location-specific, but not identity-specific, with respect to its referent. Single words, on the other hand, are often identity-specific (e.g., *cat* and *ball* serve to classify their respective referents into different sets), but not location-specific unless the word is accompanied by a pointing gesture.

Glossing Characterizing Signs

In contrast to their location-specific points, the deaf child's characterizing signs were identity-specific. Recall that the characterizing sign is an iconic sign whose form is related to its referent by apparent physical similarity (e.g., a fist pounded in the air referring to the act of hammering). Through its iconicity, the characterizing sign can specify the identity of its referent, but like words and unlike pointing, the sign cannot specify its referent's location.

Using both sign form and context as a guide to lexical meaning assignment, it was easily established that subjects could gesture about actions with their characterizing signs. For example, one child held a fist near his mouth and made chewing movements while someone was eating lunch (eat); another twisted his hand over an imaginary jar in order to request that his mother twist open the jar lid (twist). Similarly, sign form and context allowed us to establish that the children could gesture about perceptual attributes with their characterizing signs. For example, one child distinguished between a large and a small kangaroo by holding his flat palms parallel to each other and wide apart (big).

Occasionally, sign form and context did not lead to the same lexical meaning assignments. For example, one child gestured the characterizing twist to identify a picture of a jar, whereas another indicated round, stubby appendages on the head to identify Mickey Mouse's ears. Sign form suggests that the twist sign refers to an action and that the round sign refers to an attribute; context, however, suggests that the two signs are both nominals, referring to the jar and to the ears, respectively. The decision in these situations was to assume that the form of the sign gives its lexical meaning (i.e., twist, round) and that context provides information about the way the sign is used (i.e., identification of an object in each instance). Thus, in the example of the twist used with the picture of the jar, although the child is indeed identifying an object with his characterizing sign, he is nevertheless using an action feature to identify that object. It is, therefore, assumed that he is conveying an action characteristic of that object (i.e., that it can be *twisted* by someone, or that one can *twist* it). Consequently, an action lexical meaning was assigned to the twisting sign. In general, we attribute to the child the lexical meaning related most closely to the form of the sign.

This assumption requires further justification. In conventional languages such as ASL or English, signs and words are (metaphor aside) handed down to us ready-made. We as sign users or word users may therefore not always be aware of the etymological history of a name and thus may not realize, for example, that the sign for a girl in ASL, "thumb drawn along the chin," was originally chosen because it represented the ribbon on a young girl's bonnet (Frishberg, 1975). Similarly, we may be quite surprised to discover the underlying justification for some common English words. For example, skyscrapers are so named for their literally sky-scraping characteristics. Names such as *girl* in ASL or *skyscraper* in English each have some nonarbitrary relationship to their respective referents. But how are we to know when to attribute knowledge of this relationship to an individual? After all, any given individual may or may not have had the "eureka"experience resulting in insight into a particular word's origin.

However, we can be quite confident that we are rightfully attributing such derivational knowledge to an individual when that individual is the inventor of the name. The first user of *skyscraper* was undoubtedly aware of the relationship between the celestial aspiring object and its name. Indeed, the inventor selected the name to emphasize just that relationship. Similarly, on these grounds we feel justified in attributing to our deaf subjects knowledge of the relationship between action and attribute sign forms and their respective referents, precisely because these children are themselves the sign inventors. The young children themselves choose to identify, or name if you will, a particular object in terms of either its action features or its perceptual attributes (see Feldman et al., 1978, for further discussion).

One consequence of this attention to sign form as the basis for lexical meanings is that we are able to extract more information from our deaf children's sign sentences than one could ever possibly hope to infer from an equally long string of a hearing child's words. For example, when the hearing child identifies an object by saying *that ball* (glossed, "that is a ball"), the adult listener might infer several things from the word *ball*: that it is *round,* that it is *thrown,* that it *rolls,* or indeed any aspect at all of ballness, including some aspects which, though second nature to adult users of *ball,* may be totally foreign to the speaking child's experiences. Adults cannot determine what, if anything, the speaking child means about the ball from these words alone. In contrast, the forms of the deaf child's characterizing signs, if taken literally, allow us readily to discriminate among the several meanings. For example, deaf children might point at the ball and then draw a circle in the air (the sign *round*) to convey "that is round"; they might point at the ball, then make a throwing motion in the air (*throw*) to convey "that can be thrown by someone"; or they might point at the ball, then trace with their hands the forward motion of the ball as it would roll along the ground (*roll*) to convey "that can roll."

Assigning Relational Meanings to Signs and Sentences

In the final coding decision we classified gesture sequences according to the semantic relations conveyed. Gesture sequences that contained single markers and/or deictic signs used only to point out the existence of an object, person, place, and the like ("deictic indicators") were not coded any further and were not assigned relational meanings. All other gesture sequences—those containing deictic and characterizing signs alone or in combination—were assigned one (or more in the case of multiproposition, i.e., complex, sentences) of the relational meanings defined in the following examples. For each relation, in addition to presenting an example from our deaf children's gesture corpus, we present examples of spoken sentences produced by young hearing children, which have been interpreted as conveying these same relations (examples and coding from Bloom, Lightbown, & Hood, 1975).

Action Relations

a. Transfer. An act by an actor on a patient which results in the patient's transfer to a new location or person.

1. TRANSFER-puzzle board (I/Marvin *transfer* piece to *puzzle board*) [Marvin IIIb.2].[2]

[2]The following conventions are used in describing examples:

a. The examples should be read from left to right; the sign that occurs first in the temporal sequence is the first entry on the left.
b. The referents of deictic signs are in lower-case letters (e.g., puzzle board); capitalized words (e.g., TRANSFER) are glosses for the referents of characterizing signs.
c. The sentence in parentheses is an English gloss of the sign sentence. The italicized words stand for those referents which are explicitly signed in the sentence; the remaining words stand for referents which are omitted from the sentence and must be inferred from context.
d. The information in brackets indicates the name of the child who produced the sentence (e.g., Marvin), the session in which he or she produced the sentence (e.g., IIIb), and the transcription number of the sentence (e.g., 2).

As an example of a transfer relation in a young hearing child's speech, Kathryn said *put in box* (p. 11) as she was throwing a car and a truck into a box. Bloom, Lightbown, and Hood code sentences of this type either as conveying (transitive) Locative Action relations (Agent-Locative Action-Object-Place) or, if the recipient of the transferred patient is animate (*bring Jeffrey book,* Appendix), as conveying Dative relations.

b. Transform. An act by an actor on a patient which affects the state of that patient.

2. Bubbles-TWIST (you/Marolyn *twist bubbles*) [Karen IIc.8].

As an example of a transform relation in a hearing child's speech, Kathryn said *open drawer* (p. 10) while she herself was opening the drawer (coded as conveying an [transitive] Action relation [Agent-Action-Object]).

c. Transport. An act by an actor which results in the actor's relocation.

3. COME-mother (*you/mother come* to my side) [Marvin Ic.8].

As an example of a transport relation in a hearing child's speech, Eric said *you come here* (Appendix) while looking out a window and shouting to a man who had walked away. Sentences of this type are coded as conveying (intransitive) Locative Action relations (Mover-Locative Action-Place).

d. Perform. An act by an actor which affects the actor's own state and not the state of an external patient.

4. Train-CIRCLE (*train circles*) [Marvin IVa.89].

As an example of a perform relation in a hearing child's speech, Peter said *tape go round* (p. 11) while watching the reels of a tape-recorder. Or, Kathryn said *Kathryn jumps* (p. 11) after she had just jumped. Bloom, Lightbown, and Hood code sentences of this type as conveying (intransitive) Action relations (Actor-Action).

Attribute Relations

a. Description. A description of the size, shape, posture, etc. of an entity.

5. Ketchup bottle-LITTLE (*ketchup bottle is little*) [Karen Va.49].

As an example of a description relation in a hearing child's speech, Eric said *little that* (Appendix) while holding up a sheep (coded as conveying an Attribute relation).

b. Similarity. A similarity relation between two entities.

6. Elephant's back-Abe's back (*elephant's back* is like *Abe's back*) [Abe IXd.56].

The function of the similarity relation for the deaf child seems to be to classify an entity as one of a set, without necessarily specifying the criterial attributes of that set. If deaf children use a description relation to classify an entity as a Mickey Mouse, for example, they specify (with their characterizing sign) an attribute which that entity shares with all instances of Mickey Mouse (e.g., round ears). In contrast, deaf children can use the similarity relation to indicate the likeness of an entity to other entities without specifying the basis of similarity between the two entities, that is, without specifying the dimension(s) on which the two entities share attributes. A hearing child learning English can achieve this function by naming an entity (rather than by describing the entity with an adjective, which would be comparable to our description relation) and thereby by classifying it as one of a set of entities. Thus, when Kathryn says, *that ə mirror* (Appendix) while picking up a mirror, her spoken sentence seems to be functioning as does the deaf children's similarity sentence. Bloom, Lightbown, and Hood code sentences of this type as conveying Existence relations.

c. Picture Identification. A likeness relation between an entity and a picture representing that entity.

7. Picture of potato chip-potato chip (*potato chip picture* is like *potato chip*) [Abe IXb.25].

The picture identification relation is, in fact, a subset of the similarity relation: The deaf child is classifying an entity represented in a picture as one of a set of entities (again without specifying the criterial attributes of the set). As an example of a picture-identification relation in a hearing child's speech, Kathryn said *that dogs* (Appendix) looking at a picture of dogs (coded as conveying an Existence relation).

d. Location. A location relation between an entity and its place of location.

8. Picture of bandaid-Mildred's finger (*bandaid* belongs on *finger*) [Mildred XIIc.40].

As an example of a location relation in a hearing child's speech, Peter said *light ə hall* (p. 12) while pointing to the overhead light in the hallway (coded as Locative State).

e. Possession. A possession relation between an entity and its possessor.

9. Picture-Abe (*picture* belongs to *me/Abe*) [Abe IXb.37].

As an example of a possession relation in a hearing child's speech, Gia said *mommy scarf* (Appendix) after walking into the kitchen, seeing her mother's scarf, and reaching for it (Possession relation coding).

Following Bloom (1970), we used the context in which a sequence was produced as the primary basis for assigning these relations. In Bloom's system, if a hearing child said *mommy sock* while mother was putting on the child's own sock, Bloom would assign that sentence an Action (in our system, a transform) relational meaning, "you/mother are putting on my sock." If, however, the child said *mommy sock* while mother was holding her own sock, Bloom would assign the sentence a Possession relational meaning, "mommy's sock" or "the sock is mommy's." Similarly, in our study, if a child pointed first at a jar, then at mother, and context indicated that he wanted mother to move the jar to the table, that gesture sequence would be assigned a *transfer* relational meaning, "you/mother move the jar to the table." If, however, the child pointed at that same jar, then at mother, but this time context indicated that he wanted mother to open the jar, the gesture sequence would be assigned a *transform* relational meaning, "you/mother open the jar."

Case and Predicate Semantic Elements

Afer a relational meaning was assigned to the gesture sequence, deictic signs in all action relations were assigned semantic *case* meanings (actor, patient, or recipient), and characterizing signs in action relations were classified as *act predicates*. The case and predicate semantic elements we used in this study are reminiscent of those proposed by Fillmore (1968) to describe adult case grammars and of those proposed by Brown (1973) to describe the early spoken sentences of hearing children. Our case and predicate terms are defined and exemplified in the following sign sentences from our deaf subjects and spoken sentences from Bloom, Lightbown, and Hood's hearing subjects:

Act Predicate. The act that is carried out to effect a change of either state or location (e.g., *TRANSFER*-puzzle board and "*put* in box" in example 1, bubbles-*TWIST* and "*open* drawer" in example 2, and train-*CIRCLE* and "tape *go round*" in example 4).

Patient Case. The object or person that is acted upon or manipulated (e.g., *bubbles*-TWIST and "open *drawer*" in example 2).

Recipient Case. The locus or person toward which someone or something moves, either by transporting himself/herself/itself or by being transferred by an action (e.g., TRANSFER-*puzzle board* and "put in *box*" in example 1).

Actor Case. The object or person that performs an action in order to change its own state or location, or to change the state or location of an external patient (e.g., COME-*mother* and "*you* come here" in example 3, and *train* CIRCLE and "*tape* go round" in example 4).[3]

Although context typically provided information sufficient to determine relational meanings, occasionally it proved inconclusive. In many of these unclear instances, however, gesture *form* allowed us to decide between two interpretations of a given sentence. Two of the more common instances where gesture form entered our decision-making process follow.

Deciding Between Transitive and Intransitive Action Meanings

Consider a situation in which a child gestures to comment on the actions of a mechanical duck. Mother has just wound the duck (a transitive act on the object), and the duck has moved forward (an intransitive act performed by the object). Context cannot easily tell us where the child is describing the act *on* or *by* the duck, but gesture form of the characterizing sign can help. If the child produces a twisting gesture, pivoting finger and thumb, we can assume that the child is describing the mother's transitive action on the duck, a *transform* relation; the child's point at the duck would then be considered a *patient* case. If, on the other hand, the child produces a movement forward in the gesture, we can assume that the child is describing the duck's intransitive walking action, a *transport* relation; the child's point at the duck would then be an *actor* case.

Deciding Between Directional and Nondirectional Action Meanings

A similar situation arises when we consider a child gesturing to comment on a toy frog moving forward by hopping. The child could either be describing the fact that the frog is transporting itself across space or the fact that the frog is performing a hopping motion. Again, gesture form might provide guidance where context proves insufficient. If the child produces a forward-moving motion in the gesture, a flat palm crossing space, we can assume the child is describing the directional path of the frog, a *transport* relation. If, on the other hand, the child produces a gesture oscillating vertically in one place, a flat palm "hopping" in one place, we can assume the child is describing the nondirectional action of the frog, a *perform* relation. (Note that a deictic point at the frog would be considered an *actor* case in either situation.)

[3]Occasionally, the children produced a fourth case, the *place* case (the locale where an action is carried out, but not the end point of a patient's or actor's change of location, e.g., EAT kitchen, meaning "I eat cookies in the kitchen"). The place case, although produced infrequently, was produced in sentences expressing each of the four action semantic relations.

In the instances when neither context nor gesture form could disambiguate between two interpretations, the gesture sequence was eliminated from the relational and structural analyses.

Vocalization Coding Categories

All of each child's vocalizations were noted, and two coding decisions were made on each vocalization. First, we noted whether or not a vocalization occurred in the same sequence as a gesture. Second, we noted whether a vocalization was meaningful or not. Meaningless vocalizations were either unrecognizable sounds spontaneously produced by the child or sounds elicited by the child's caregiver who, in an attempt to encourage lipreading and vocalization in her child, would often hold an object near her mouth, point to her lips, and mouthe in exaggerated fashion the word for that object. Reliability in coding vocalizations ranged from 88% to 99% agreement between two coders.

The first 30 minutes of every session, the period of intensive mother-child interaction, were coded completely as described. The remaining reels of video tape were coded omitting all single signs and all vocalizations.

THE DEAF CHILD'S COMMUNICATION SYSTEM

All four deaf children in this study were found to use both vocalizations and gestures to communicate. However, in every instance, as I show in the following sections, gestures appeared to be the child's primary means for communicating information.

Gestures: An Overview

The gestures of the four deaf children differed from their vocalizations in two significant respects. First, the children's gestures were interpretable (and thus differed from their predominantly meaningless vocalizations). Second, their gestures were often concatenated into sentences (and thus differed from their few meaningful vocalizations, which were used only as single, unconnected words, and never concatenated).

Each of our four children produced the three types of signs found in the gesture systems of our original six subjects (marker, deictic, and characterizing signs), alone and in sign sentences. Table 7.1 presents each child's rate of production of gesture sequences for each observation session. The table also indicates the mean length of those gesture sequences for each session (MLG), as well as the Upper Bound (the longest gesture sequence produced) for each session. The gesture analysis that follows concentrates on two aspects of the deaf children's gesture systems: *semantic content,* that is, the types of notions conveyed by the children's gestures, and *structural form,* the formal means by which these notions were conveyed.

Semantic Content

Each of the four children conveyed at least eight of the nine types of semantic relations described in our original study of six deaf children. Semantic relations could be conveyed by a sentence of at least two signs (deictic and/or characterizing), as the examples in the section on gesture coding categories indicate, or by a single deictic or characterizing sign taken in context. For example, if the child has made it clear (by gentle nudges and whines) that he wants mother to sit near him and then points at the spot at his side, we assume his point is representing the recipient (end point) case of a transport relation.

Table 7.2 presents the proportions of single signs and of simple sign sentences (those conveying only one semantic relation) for the four Chicago subjects and the proportions of simple sign sentences for the six Philadelphia subjects (single signs were not coded for these subjects) which convey each of the nine relations. It can be seen that the children tended to convey the same relations in the same proportions. The transitive action relations (transfer and transform) were most often conveyed, whereas the intransitive action relations (transport and perform) and the five attribute relations were conveyed far less frequently by all but one (Tracy) of the ten children. Furthermore, the four Chicago children tended to convey each of the semantic relations in roughly the same proportions in both their single signs and their simple sign sentences.

In all natural languages, when word-like units are strung together to create sentences, those units are strung together in a structured and rule-governed fashion. We now attempt to determine whether the deaf subjects' simple sign sentences possess this most important of all properties of language—structure.

We have previously shown that the simple sentences of our original six subjects were indeed structured at both underlying and surface levels. I begin by

TABLE 7.2
Semantic Relations[a]

		Action Relations				Attribute Relations					
		Transfer	*Transform*	*Transport*	*Perform*	*Description*	*Similarity*	*Picture Identification*	*Location*	*Possession*	*Total (n)*
Chicago Subjects											
Mildred	Single Signs	.26	.32	.02	.17	.02	.06	.11	.04	.00	53
	Sign Sentences	.25	.35	.10	.10	.05	.00	.15	.00	.00	20
Abe	Single Signs	.40	.40	.12	.02	.00	.00	.00	.02	.04	52
	Sign Sentences	.32	.20	.12	.00	.08	.20	.08	.00	.00	25
Marvin	Single Signs	.44	.29	.07	.06	.02	.01	.06	.04	.00	134
	Sign Sentences	.45	.29	.03	.08	.11	.03	.00	.03	.00	38
Karen	Single Signs	.44	.24	.02	.04	.08	.00	.02	.10	.06	50
	Sign Sentences	.28	.24	.08	.12	.08	.00	.04	.08	.08	25
Philadelphia Subjects											
Dennis	Sign Sentences	.51	.32	.03	.00	.00	.10	.00	.03[b]		31
Kathy	Sign Sentences	.46	.27	.07	.07	.02	.05	.02	.05		42
Chris	Sign Sentences	.40	.16	.05	.09	.02	.14	.09	.04		43
Donald	Sign Sentences	.30	.22	.06	.04	.14	.13	.09	.01		138
David	Sign Sentences	.22	.23	.09	.04	.16	.07	.14	.05		437
Tracy	Sign Sentences	.03	.21	.05	.09	.20	.09	.28	.05		65

[a]Each entry is the total number of single signs (or the total number of simple sign sentences) conveying a particular semantic relation produced during the first half hours of all observation sessions for the Chicago subjects and produced during the entirety of all sessions for the Philadelphia subjects, over the total number of single signs (or simple sign sentences) conveying semantic relations produced during those periods.

[b]Location and possessions relations were not distinguished in our original study of the six Philadelphia subjects. These two relations were called static relations in Goldin-Meadow (1979).

considering data from the four new subjects on underlying structure and then turn to data on surface structure, including both ordering and production probability surface rules.

Simple Sentences: Underlying Structure

Bloom (1970), in her analyses of the early sentences of young English speakers, was the first to suggest that the hearing child's two-word sentences could be characterized by an underlying structure richer than the surface structure actually produced by the child (see pages 230–238, Underlying Structure, for further discussion). I follow Bloom in arguing that the early sign sentences of both my old and new deaf subjects can also be characterized by underlying structures (in fact, the same underlying structures as are found in the sentences Bloom's subjects produce, see the section on Underlying Structure). As in Bloom's data, the deaf children's underlying structures also turn out to be richer than the surface structures of their sign sentences.

The first evidence for this appears in the particular arrays of two-sign sentences the children produced to convey a given relation. Though few of the subjects ever explicitly gestured in one sentence all of the semantic elements posited for a four-element relation such as *give,* they did sign each of these posited elements at one time or another when describing a "giving" event. For example, Mildred exhibited knowledge that *actor, patient,* and *recipient* are associated with the *act* of transfer by overtly expressing each of these four elements in describing "transferring": *patient-act* (point at cowboy-GIVE, meaning "you/mother *give cowboy* to me/Mildred," VIb.10); *act-recipient* (GIVE-point at own chest, meaning "you/Susan *give* apple bank to *me/Mildred,*" IXc.28); *recipient-actor* (point at own eyes-point at Marolyn, "*you/Marolyn* put glasses on *eyes,*" XIc.11); and *patient-recipient-actor* (point at glasses-point at own eyes-point at mother-point at glasses-point at mother," "*you/mother* put *glasses* on *eyes,*" Xc.12). Thus, Mildred, as well as the other three children, conveyed transfer relations by concatenating any two, and occasionally three, of the four case and predicate elements—patient, act, recipient, and actor. It is these four elements that we posit as the underlying structure of transfer sentences.

Transform relations, notions about an actor affecting the state of an object, were also conveyed as concatenations of different cases and predicates (examples from Karen): *patient-act* (point at bubbles-TWIST, "you/Susan *twist bubbles,*" IC.21); *actor-patient* (point at Marolyn-point at bubbles, "*you/Marolyn* twist *bubbles,*" Ic.4); and *act-actor* (TWIST-point at own chest, "*I/Karen twist* robot," VIa.3). Thus, transform relations appear to be conveyed by concatenating any two of three elements—patient, act, and actor—and it is these three elements that we posit as the underlying structure for transform sentences.

Transport relations, notions about an actor (object or person) relocating himself/herself/itself, were conveyed in sentences of the following types (examples from Abe): *recipient-actor* (point outside-point at own chest, "*I/Abe* move *outside,*" IXc.4); *actor-act* (point at train-GO, "*train goes* to end of path," IXa.77); *act-recipient* (GO-point at bottle slot, "coin *goes* to *bottle slot,*" VIIc.8); and *recipient-actor-act* (point at candles-point at friend-MOVE, "*you/friend move* to *candles,*" VIIIb.18). Transport relations thus are posited to have three-element underlying structures containing actor, recipient, and act elements.

Finally, perform relations, notions about an actor's (object or person) movements that affect only himself/herself/itself, tend to be conveyed by one surface form: *actor-act* (point at train-CIRCLE, "*train circles,*" Marvin IVa.128; this sentence was produced to describe a battery powered train

which can circle on its own). Perform relations consequently are posited to have two-element underlying structures containing actor and act elements.

The two-, three-, and four-element underlying structures we have posited for the deaf children's gesture systems receive further empirical support from the distributional patterns of these subjects' two-sign sentences. As the foregoing examples suggest, the deaf children were producing primarily two-sign sentences (just as in a comparable period of development, the hearing child produces primarily two-word sentences, e.g., Bloom, 1970; Brown, 1973). The two-sign child will clearly not be able to explicitly sign *in one sentence* all four of the elements we posit as part of the underlying structure of transfer relations. *Production probability* is the measure that reflects this surface structure limitation, and it is defined as the likelihood that a case or predicate will be explicitly signed in a sentence of a certain length, conveying a given relation (see Fig. 7.1). We take production probability as an index of underlying structure on the basis of the following chain of logic. If, for example,

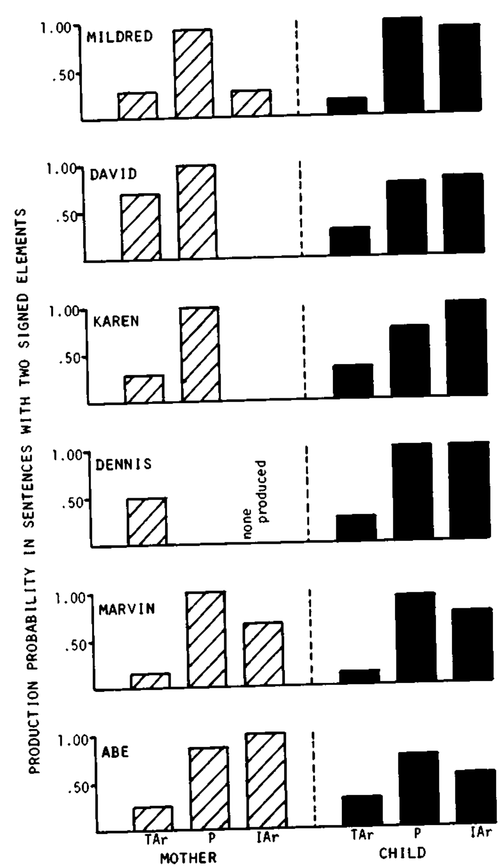

FIG. 7.1 Production probability patterns in mother and child simple sign sentences. Production probability was calculated on the following number of sign sentences with two explicit elements: Mildred, mother 14 for the transitive actor and patient, 4 for the intransitive actor, child 22, 2; David, mother 10, 1, child 54, 16; Karen, mother 7, 1, child 23, 4; Dennis, mother 2, 0, child 10, 1; Marvin, mother 6, 8, child 30, 4; Abe, mother 8, 2, child 29, 19. (*TAr* = Transitive Actor, *P* = Patient, *IAr* = Intransitive Actor.)

transfer relations were in truth to have an underlying structure of only two elements (e.g., actor and act elements), we would then expect the actor case to be explicitly signed in 100% of the child's two-sign sentences conveying transfer relations. If, however, transfer relations were to have three elements in underlying structure (e.g., combinations of actor, act, and patient elements), we would now expect the actor case to be signed in less than 100% of the child's two-sign transfer sentences simply because three elements would be competing for the limited number of slots (two) in surface structure. Following the same logic, if transfer relations were to have four elements in underlying structure, we would expect the actor case to be explicitly signed even less frequently in two-sign transfer sentences, again because of the increased competition for the limited number of surface slots. Thus, actor production probability in surface structure ought to vary depending on the number of elements in underlying structure.

In short, if we find that actor production probability does vary across types of semantic relations in the direction we predict, we then have evidence supporting the notions of underlying structure in the deaf children's gesture systems. After all, if there were no underlying structure affecting the surface structure of the deaf children's sign sentences, there would be absolutely no reason to expect actor production probability to vary at all across different semantic relations (see the section on Underlying Structure for further discussion). Thus, we look to determine whether the probability of producing actors remains constant or varies across the four action semantic relations we have isolated in the deaf children's gesture systems.

Given our observations of the range of two-sign sentences conveying each of the four relations, we would expect actor production probability to be lowest in transfer sentences hypothesized to have four-element underlying structures, higher in transform and transport sentences hypothesized to have three-element underlying structures, and highest in perform sentences hypothesized to have two-element underlying structures. The data in Table 7.3, production probability as a function of hypothetical underlying structures in sentences with two signed elements, conform to this pattern for each of the four Chicago children.[4]

[4]Actor production probability in perform sentences hypothesized to have two-element underlying structures was not 100% simply because occasionally the *place* case (representing the place where the action occurs) was concatenated with either the actor or the act. Note that the *place* case can and does tend to occur with each of the four relations (each action must occur in a place). I have not included the *place* case as part of the underlying structures for each of the four relations primarily because the case was signed relatively infrequently. It is important to note that adding one element to each of the hypothetical underlying structures would not change the structure of the argument presented here, simply because the addition would not change the relative positions the underlying structures hold to one another.

When production probability is calculated for the patient case and the act predicate, similar patterns are observed. Table 7.3 also presents act production probability in sentences with two signed elements for all four Chicago children, as well as comparable data on the patient (note that patients cannot occur in intransitive perform and transport relations assumed to have two-element and three-element underlying structures, respectively). In three out of four instances for the act and in all four instances for the patient, production probability increases systematically as the number of elements hypothesized in underlying structure decreases. Thus, the distributional facts of the deaf children's sign sentences suggest that the gesture systems developed by these four subjects possess underlying structure, as do the gesture systems of our original six deaf subjects (see also Table 7.3) and the speech systems of young hearing children (Bloom, Miller, & Hood, 1975; see also the section on Underlying Structure).

It is important to note that a priori there is no reason to expect different types of actors, patients or acts to be signed with different probabilities, as is the case in our deaf subjects' sign sentences and in Bloom, Miller, and Hood's (1975) hearing children's spoken sentences. For actors, there is no obvious reason to expect *dancers* to be more likely signed than *goers* or *eaters,* nor is there reason to expect *goers* or *eaters* to be more likely signed than *givers*. It is only when a *dancer* is considered a member of a two-element underlying configuration, a *goer* a member of a three-element configuration, and so on that these variations in surface probabilities become coherent. Similarly, for patients, there is no a priori reason to expect an *eaten apple* to be more likely signed than a *given apple*. Yet in nine of the ten children's sign sentences, we find this to be the pattern. Finally, for acts, there is no reason to expect dancing acts to be more likely signed than going or eating acts, nor going or eating acts to be more likely signed than giving acts. It is only when actors, patients, and acts are classified as members of differently sized underlying configurations that these surface variations become predictable and interpretable.

Up to this point, I have mounted evidence for an organized level of representation that underlies the surface level of a sentence and affects the probability with which a semantic element will appear in this level. I now turn to a description of the surface level itself, looking first at the ordering and then at the likelihood of occurrence of particular elements in surface structure.

Simple Sentences: Surface Structure

Construction Order Patterns

The four children in this study (like the Philadelphia children) showed a tendency to order patients, acts, and recipients in their two-sign sentences. Table 7.4 presents the data for the Chicago children's two-sign sentences con-

TABLE 7.3
Underlying Structure in Simple Sentences with Two Signed Elements[a]

	Actor Production Probability			Act Production Probability			Patient Production Probability	
	4-element	3-element	2-element	4-element	3-element	2-element	4-element	3-element
Chicago Subjects								
Mildred	.05	.25	1.00	.85 √	.79	1.00	.85	.91
Abe	.03	.40	1.00	.65	.77	1.00	.65	.76
Marvin	.00	.21	.75	.59	.91	1.00	.68	.93
Karen	.03	.44	.67	.71	.85	1.00	.69	.74
Philadelphia Subjects								
David	.02	.43	1.00	.47	.87	1.00	.78	.83
Donald	.08	.24	1.00	.75	.94	1.00	.53	.90
Kathy	.13	.50	1.00	.81 √	.75	1.00	.63	.87
Dennis	.08	.27	–	.46	.73	–	.85	1.00
Tracy	.00	.38	1.00	1.00 √	.80	1.00	1.00 √	.85
Chris	.00	.13	1.00	.71	1.00 √	1.00	.64	1.00

√ = Violation of the underlying structure pattern.

[a] Production probability was calculated on the following number of sentences with two signed elements: Mildred for the actor and act 4-element 20, 3-element 24, 2-element 5 and for the patient 4-element 20, 3-element 22; Abe for the actor and act 34, 8, 1 and for the patient 34, 29; Marvin for the actor and act 41, 34, 5 and for the patient 41, 30; Karen for the actor and act 35, 27, 6 and for the patient 35, 23; David for the actor and act 88, 123, 17 and for the patient 88, 88; Donald for the actor and act 40, 37, 5 and for the patient 40, 29; Kathy for the actor and act 16, 12, 3 and for the patient 16, 9; Dennis for the actor and act 13, 11, 0 and for the patient 13, 10; Tracy for the actor and act 2, 16, 6 and for the patient 2, 13; Chris for the actor and act 14, 8, 4 and for the patient 14, 7.

TABLE 7.4
Sign Order Patterns in Simple Sentences[a]

	PA	*AP*[a]	*PR*	*RP*	*AR*	*RA*
Chicago Subjects						
Mildred	19	8*	2	0	1	0
Abe	11	12	6	2	10	4
Marvin	21	12	13	2**	10	4
Karen	17	8+	6	1++	6	1++
Philadelphia Subjects						
David	44	18***	36	1***	11	2*
Donald	26	15*	7	0*	10	1**
Kathy	8	4	2	0	4	2
Dennis	10	1**	4	0++	1	1
Chris	6	4	2	1	4	1
Tracy	7	1+	0	0	0	0

[a] P = patient, A = act, R = recipient. Each entry is the number of two-sign sentences following a particular sign order pattern (e.g., *PA*, patient precedes act) produced by each child.
++ $p = .13$
+ $p < .10$
* $p < .05$
** $p < .01$
*** $p < .001$

taining concatenations of patients, acts, and recipients, as well as comparable data for the Philadelphia children. We find that if a Chicago child used a consistent construction sign order when concatenating two of these semantic elements, the construction order turned out to be one of the several construction order patterns described in our original study: Signs for the patient tended to precede signs for the act (Mildred $p < .05$, Karen $p < .10$, trend, Binomial Test, two-tailed); signs for the patient tended to precede signs for the recipient (Marvin $p < .01$, Karen $p = .13$, trend); and signs for the act tended to precede signs for the recipient (Karen $p = .13$, trend). Only Abe showed no strong tendency to order patients, recipients, and acts. Abe, however, did show the only construction order pattern involving the actor case; he produced 10 sentences with signs for the actor before signs for the act and none in the reverse order, $p = .002$. Tracy, in our original sample, also showed an actor-act construction order (ArA 9 vs. AAr 0, $p = .004$). Thus, the same ordering patterns observed in the data of our original six subjects are found in the data of these four new subjects.

It should be noted, however, that although the children tended to generate the same preferred construction order for a given pair of semantic elements, there was at least one idiosyncratic exception. Table 7.4 indicates that Chris has no patient-act ordering tendency: He produced six PA sentences and four

AP sentences. However, if the types of relations of these sentences are examined more closely, two consistent construction order patterns emerge. Chris tended to adhere to a PA construction order in producing sentences conveying transfer relations (e.g., "apple-GIVE," 6 PA vs. 0 AP) but tended to adhere to an AP construction order in producing sentences conveying transform relations (e.g., "EAT-apple," 0 PA vs. 4 AP). Thus, patients and acts were ordered differently in Chris' sentences conveying transfer and transform relations (Fisher Exact, $p = .005$, one-tailed).

Production Probability Patterns

We defined production probability as the likelihood that a particular case (or predicate) will be signed in a sentence when that case (or predicate) can be signed in that sentence (a determination made on contextual grounds, see Coding Categories). In our study of the six Philadelphia deaf children, we found a tendency for the production probability of certain cases to vary even when the structure of the relation underlying a sentence was held constant. In particular, we found that in transform sentences (transitive sentences which appear to have three elements at an underlying level—actor, act, patient), the patient case was very likey to be signed when it could be (i.e., the patient had a high production probability), whereas the transitive actor case was relatively unlikely to be signed (i.e., the transitive actor had a low production probability). Table 7.5 shows that this same pattern was found in the four Chicago subjects' sign sentences (and presents the original data for the six Philadelphia subjects).

An interesting point arises from extending this production probability analysis of surface structure to the intransitive relation, transport (also a relation with three elements in underlying structure—actor, act, recipient).[5] Table 7.5 also reveals that, in three of the four Chicago children (Abe's data are less clear-cut) and in all six Philadelphia children, production probability of the intransitive actor case in transport sentences resembled production probability of the patient case in transform sentences; it was also much higher

[5]We limit our analysis to transitive and intransitive relations which have the same number of elements in underlying structure (two arguments and one predicate) simply because we have found (as reported in the preceding section) that production probability of a given element in two-sign sentences is affected by the number of elements hypothesized to be in underlying structure. For example, within the transitive relations, the actor in transfer relations hypothesized to have four elements in underlying structure is less likely to be produced in two-sign sentences than the actor in transform relations hypothesized to have three elements in underlying structure (.03 vs. .24 for the Chicago subjects, and .05 vs. .24 for the Philadelphia subjects). Similarly for intransitive relations, the actor in transport relations hypothesized to have three elements in underlying structure is less likely to be produced in two-sign sentences than the actor in perform relations hypothesized to have two elements in underlying structure (.66 vs. .82 for the Chicago subjects, and .80 vs. 1.00 for the Philadelphia subjects).

TABLE 7.5
Production Probability Patterns in Transform and Transport Sentences[a]

Chicago Subjects	*Transitive Actor*	*Transitive Patient*	*Intransitive Actor*
Mildred	.18	.91	1.00
Abe	.31	.76	.53
Marvin	.13	.93	.75
Karen	.35	.74	1.00
Philadelphia Subjects			
David	.28	.83	.80
Donald	.10	.90	.75
Dennis	.20	1.00	1.00
Chris	.00	1.00	1.00
Kathy	.44	.77	.67
Tracy	.30	.85	1.00

[a]Production probability was calculated on the following number of sentences with two signed elements: Mildred for the transitive actor and patient in transform sentences 22, and for the intransitive actor in transport sentences 2; Abe 29, 19; Marvin 30, 4; Karen 23, 4; David 88, 35; Donald 29, 8; Dennis 10, 1; Chris 7, 1; Kathy 9, 3; Tracy 13, 2.

than the relative probability of production of the transitive actor in transform sentences. Comparing transport and transform—two relations with underlying structures of equal size—it is apparent that the transitive actor and the intransitive actor are clearly distinguished by the deaf children. The children consistently treat the intransitive actor like the patient, not like the transitive actor.

This production probability pattern in which the intransitive actor (e.g., "*boy* run [to W]") resembles the patient (e.g., "[X] open *jar*") but not the transitive actor (e.g., "*boy* open [Y]") is a probabilistic analogue of the structural case-marking patterns of ergative languages (Dixon, 1979; Silverstein, 1976) and is, in fact, distinct from the accusative case-marking pattern seen in English. The hallmark of the distinction between ergative and accusative languages is the manner in which the intransitive actor is treated (Fillmore, 1968). Consider the intransitive sentence *you go to the table*. In this sentence, 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, "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 to a certain extent arbitrary.

In English, the effector properties of the intransitive actor "you" are emphasized by treating it like other effectors. For example, the intransitive actor "you" in *you go to the table* is treated just like the transitive actor "you" in *you eat grapes*; that is, both actors precede the verb. In contrast, ergative languages emphasize the affectee properties of the intransitive actor by treating it like other affectees (i.e., patients). Thus, the intransitive actor of a going relation (you) is treated just like the transitive patient of an eating relation (grapes). In sum, accusative languages such as English highlight the effector properties of the intransitive actor by treating it like transitive actors, whereas ergative languages, with which the deaf child's gesture system appears to share certain characteristics, highlight the affectee properties of the intransitive actor by treating it like transitive patients.

Concordance Between Production Probability and Construction Order Patterns

To summarize, we have found that the deaf child's probability-of-production pattern appears to be a probabilistic analogue of the structural case-marking patterns of ergative languages. This ergative-like pattern, if a characteristic of the deaf child's entire gesture system, might also be expected to appear in the second formal property of the deaf child's system—construction order patterns. If so, intransitive actors should be ordered in a similar construction position to that of patients (which tend to occur just before signs for acts) and in a different construction position from that of transitive actors (which should then occur in some differentiable position, e.g., after signs for acts). Only David produced a sufficient number of sentences with transitive and intransitive actors to address this question (50 such sentences compared to 11, the maximum number of actor plus act sentences any of the other children produced). David tended to produce signs for intransitive actors before signs for acts (32 Ar_I A vs. 7 AAr_I) and signs for transitive actors after signs for acts (3 Ar_T A vs. 8 AAr_T). The construction order for intransitive actors and acts (Ar_I A), which was reliably different from the construction order for transitive actors and acts (AAr_T), $X^2 = 9.6$, $df = 1, p < .01$, was precisely the same as the construction order for patients and acts (PA) in David's system. David's gesture system thus appears to follow ergative patterns with respect to two formal aspects of the system—construction order and production probability patterns.

The only other reliable actor construction orders found in the data were those already mentioned for Abe and Tracy. Both tended to produce signs for actors—transitive as well as intransitive—before signs for acts (Ar_T A vs. AAr_T, 2 vs. 0 for Tracy, 4 vs. 0 for Abe; Ar_I A vs. AAr_I, 7 vs. 0 for Tracy, 6 vs. 0 for Abe.). This pattern would be considered analogous to the accusative pattern of a language such as English if intransitive actors in the system, in addition to being treated like transitive actors, were also treated differently from patients. Recall that signs for patients in Tracy's system tended to precede signs for acts; thus, patients were not distinct from intransitive actors in terms of construction order in Tracy's system. Abe, however, had no patient-act ordering preference in his system; thus, patients were distinct from intransitive actors, and Abe's system was analogous to accusative systems when considered in terms of construction orders. Note that, with respect to production probability patterns, Abe's gesture system was the only system not found to have ergative properties. Thus, it is possible that Abe's gesture system is organized around a different set of principles from those that structure the gesture system of David and possibly the other children as well.

Complex Sentences: Rules of Recursion

In addition to their simple sign sentences, each of the four deaf children in the replication produced a number of complex sentences in which they conveyed at least two semantic relations (or propositions) before they relaxed their hands or returned them to neutral positions. Mildred, Abe, Karen, and Marvin produced 11, 45, 31, and 38 complex sentences containing two or more semantic relations, accounting for 12%, 25%, 22%, and 23% of each child's sentences, respectively. In our original study, David, Donald, Dennis, Chris, Kathy, and Tracy produced 240, 12, 4, 8, 11, and 10 complex sentences, accounting for 31%, 7%, 11%, 14%, 17%, and 12% of each child's sentences, respectively.

Two of the four children in our Chicago study were producing complex sentences during the first sessions they were observed: Marvin at 2;11 and Karen at 3;1. The other two children began producing complex sentences over the course of our observations: Mildred at 2;2 and Abe at 2;5. These onset times are, in general, comparable to those observed in the original study: Four of the six Philadelphia subjects were producing complex sentences during the first sessions they were observed (Dennis at 2;2, David at 2;10, Chris at 3;2, and Tracy at 4;1), and the other two children began producing complex sentences during our study (Kathy at 2;2, an age comparable to the onset ages of our Chicago subjects, and Donald at 3;11, an age later than those of our Chicago subjects; it should be noted, however, that Donald was not observed between 3;1 and 3;11, and therefore he might have begun producing complex sentences as early as 3;2).

The most common type of complex sentence observed in the children's gestures concatenated two actions. For example:

10. Susan-WAVE-Susan-CLOSE (*you/Susan wave* then *you/Susan close door*) [Abe IX.256].

Mildred, Abe, Marvin, and Karen produced 6, 28, 28, and 15 of these action-plus-action sentences, accounting for 55%, 62%, 76%, and 71% of their complex sentences with just two relations, respectively. The four children also concatenated two attribute relations (example 11) and three of the four concatenated an action-plus-attribute relation (example 12):

11. Wrist-picture of watch-ROUND (*watch* belongs on *wrist* and *watch* is *round*) [Marvin Vb.12].
12. GIVE-ROUND-Abe-GIVE (you/Susan *give me/Abe* cookie which is *round*) [Abe VIc.12].

Mildred, Abe, Marvin, and Karen produced 5, 5, 4, and 5 attribute-plus-attribute sentences (accounting for 45%, 11%, 11%, and 24% of their two-relation complex sentences) and 0, 12, 5, and 1 action-plus-attribute sentences (accounting for 0%, 27%, 14%, and 5% of their two-relation complex sentences), respectively. Each of our six original subjects produced action-plus-action sentences (David 85, Donald 4, Kathy 2, Tracy 5, Chris 7, and Dennis, 3, accounting for 57%, 36%, 33%, 50%, 100%, and 100% of their two-relation complex sentences, respectively), but only three of these subjects produced attribute-plus-attribute sentences (David 37, Donald 7, and Tracy, 1, accounting for 25%, 64%, and 10% of their two-relation complex sentences, respectively), and three produced attribute-plus-action sentences (David 27, Kathy 4, and Tracy, 4 accounting for 18%, 67%, and 40% of their two-relation complex sentences, respectively).

Although none of the children created explicit lexical signs for the conjunctive links between the relations of a complex sentence, it was usually easy to infer these links from the nonlinguistic context. For example, a complex sentence that described a sequence of events which, from the adult's point of view, were temporally but not causally linked, was inferred to have a "then" conjoining link (e.g., Susan-WAVE-Susan-CLOSE, meaning "you/Susan wave *then* you/Susan close the door"). Or, if the complex sentence described two coordinate relations that in some way contrasted with one another, a "but" link was inferred (e.g., pear-banana-[side-to-side head shake]-ROLL, meaning "the pear *but* not the banana rolls to my leg"). As a final example, if the complex sentences described a relation that was restricted, qualified, or elaborated on by a second relation in the sentence, a "which" link was inferred (e.g., GIVE-ROUND-Abe-GIVE, meaning "you/Susan give me/Abe cookie *which* is round"). Note that the deaf children did not produce explicit signs for the conjoining links we inferred. Our heuristic was to infer a given link, for example, "then" whenever a "then" link could plausibly be inferred for that situation by an adult. It is worth noting that in studies of the hearing child's early complex sentences, experimenters are also at times forced to use context to infer a particular conjoining link. For example, Clark (1973) reports that *and* was often used by her young hearing subjects to mean "then" (i.e., to imply temporal sequence, e.g., *I want to look at them and* [then] *come back*), a coding decision not made on the basis of the actual

conjunction expressed, but rather on the basis of an adult's view of the relationship between the two events mentioned in the sentence.

Table 7.6 presents the number of complex sentences produced by each child as a function of the type of conjunctive link each sentence was inferred to have. These types of links resemble those inferred in the complex sentences of our original deaf subjects (also presented in Table 7.6) as well as those explicitly produced in the complex sentences of comparably aged hearing children (Brown, 1973; Clark, 1973; Gvozdev, as reported by El'konin, 1973; Menyuk, 1971; Miller, 1973; Smith, 1970).

Moreover, all of the children who produced "which" complex sentences tended to use the subordinate semantic relation in sentences of this type to elaborate on the patient rather than the actor of the primary semantic relation (see, e.g., sentence 12 in which Abe used the second semantic relation *cookie is round* to further describe the characteristics of the patient [cookie] of the primary semantic relation "*you give me cookie*). Of all the "which" complex sentences Marvin produced, 80% (4/5) were of this patient-elaborating type; 73% of Abe's (8/11), 59% of David's (10/17), and 100% of Kathy's (5/5), Karen's (9/9), Tracy's (4/4), and Chris' (2/2) "which" complex sentences were of the patient-elaborating type. Hearing children learning English also tend to produce "which" complex sentences of the patient-elaborating type (Limber, 1973; Menyuk, 1969).

Vocalizations

Table 7.7 presents the proportions of each child's communications that contained gestures alone, vocalizations alone and gesture and vocalizations com-

TABLE 7.6
Conjunctive Links in Complex Sentences[a]

Chicago Subjects	*And*	*Then*	*Which*	*But*	*Or*	*While*	*Cause*
Mildred	10	1	0	0	0	0	0
Abe	8	21	11	1	1	1	2
Marvin	12	12	5	2	3	1	2
Karen	15	4	9	1	0	1	1
Philadelphia Subjects							
David	52	43	17	21	5	0	9
Dennis	0	3	0	0	0	0	0
Tracy	0	2	4	1	1	0	2
Chris	4	1	2	0	0	0	0
Donald	10	1	0	0	0	0	0
Kathy	0	0	5	0	0	0	1

[a] Each entry is the number of complex sentences with conjunctive links of each type produced by the children over the total interview sessions.

TABLE 7.7
Distribution of Gestures and Vocalizations

		Gesture + Vocalization		*Vocalization Alone*		
	Gesture Alone	*Meaningless Vocalization*	*Meaningful Vocalization*	*Meaningless Vocalization*	*Meaningful Vocalization*	*Total*[a]
Abe	.12	.20	.02	.64	.01	1242
Mildred	.34	.18	.02	.44	.02	807
Marvin	.58	.15	–	.26	.01	574
Karen	.72	.14	.01	.11	.02	469

[a]Total = total number of communications produced by each child during the first half hour of each of his or her observation sessions.

bined for the four Chicago subjects (vocalizations were not coded in our original study of the Philadelphia subjects and, therefore, are not presented here). The children varied tremendously in their production of meaningless vocalizations alone (recall that meaningless vocalizations were either unrecognizable sounds spontaneously produced by the child or imitated sounds elicited by the child's caregiver). Moreover, this variability across subjects in meaningless vocalizations alone appeared to be systematically related to the children's production of gestures alone: The more meaningless vocalizations alone a child produced, the fewer gestures alone that child produced.

Despite the great variability with respect to meaningless vocalizations, the children were quite consistent in the minimal amount of meaningful vocalizations each produced: From 1% to 4% (1 to 36 utterances) of all of the communications produced by each child contained meaningful vocalizations. Moreover, meaningful vocalizations comprised a small subset of the vocalizations each produced: From 1% to 10% of the four children's vocalizations were meaningful.

In addition, all of each child's meaningful vocalizations were single words (either nouns, verbs, adjectives, or modulators such as *no, yes, uh-oh*). Almost half (43%, 36/82) of all of the meaningful words produced by the four children were accompanied by a gesture, and in 69% (25/36) of those gesture-plus-vocalization sequences, the word conveyed the same meaning as the gesture.

In sum, although the children were indeed producing vocalizations, and thus were making progress in their oral education, their vocalizations were by and large meaningless in a referential, although perhaps not in a communicative, sense. Furthermore, at the time of these observations there was no evidence that the children could combine their few meaningful words into sentences and therefore no evidence that the children had at this point learned any of the rules of English syntax.

Summary

To summarize, I have replicated in every detail on four new subjects our basic findings on the gesture systems of six previously observed subjects: All of the children's systems were used to convey the same types of semantic notions (conveyed in both simple and complex sentences), all appeared to have underlying structure, and all appeared to have surface structure. It is important to note that the underlying and surface patterns described in this study were not based on a small number of lexical items. The children produced a relatively large number of different types of characterizing signs (Mildred 55, Abe 59, Marvin 63, Karen 45), many of which appeared in sign sentences (Mildred 29, Abe 36, Marvin 34, Karen, 24). Moreover, these lexical items tended not to occur in only one sentence combination; rather, the children produced a number of tokens of these lexical types in sign sentences (Mildred 52, Abe 69, Marvin 73, Karen, 62).[6] Thus, the rules that we have isolated to describe the deaf children's sign sentences do not appear to be tied to a small number of particular lexical items (as Braine, 1976, has suggested some of the hearing child's earliest ordering rules might be; see Goldin-Meadow & Mylander, 1984, for further discussion of this issue with respect to both the deaf children's data and data on chimpanzees learning sign language). The rules consequently appear to be general statements about sign sentences in the deaf children's gesture systems.

In terms of the relevance of this phenomenon to normal language acquisition, it is important to stress that the gesture systems developed by these deaf children are comparable in semantic content and structure to the spoken systems acquired by hearing children under typical learning conditions (also see Goldin-Meadow, 1979, and Goldin-Meadow & Mylander, 1984).[7] The deaf children, however, developed their structured communication systems without the benefit of conventional linguistic input.

I turn now to a discussion of the implications of this phenomenon. First I discuss its implications for descriptive issues in child language, specifically,

[6]It should be noted that we were rarely forced to infer a lexical item which could not be found somewhere in the child's corpus. Only two lexical types not signed anywhere in the corpus were inferred for Mildred. Comparable numbers for Abe, Marvin, and Karen were one, four, and one, respectively.

[7]There were noticeable differences in the communication systems developed by our ten deaf subjects and by hearing children in terms of the kinds of information certain lexical items could convey (e.g., the deictic point vs. the noun), the children's mean length of sentences, and their average rate of production (see Goldin-Meadow & Mylander, 1984, for details). However, the important point is that despite these differences both the deaf and hearing children were found to convey the same topics using comparable formal structures.

the issue of underlying structure, and then I discuss its implications for acquisition mechanisms in child language, specifically, environmental effects and noneffects on the development of subsets of language properties.

UNDERLYING STRUCTURE: HOW RICH SHOULD RICH INTERPRETATION BE?

In 1963 and 1964, three studies on the early stages of the hearing child's language acquisition were published (Braine, 1963; Brown & Fraser, 1963; Miller & Ervin, 1964), each of which concentrated solely on the distribution of forms in the child's spoken output, completely ignoring any meaning that these forms might have had for the child. It was not until 1970 that Lois Bloom first suggested that the forms produced by the child should be interpreted in context; in other words, that the sound-meaning pairings rather than the sound forms alone should comprise the data base for language acquisition studies. Bloom's data interpretation procedure became known as the "method of rich interpretation" and has been widely accepted as standard procedure within the field (but see Bloom, Capatides, & Tackeff, 1981; Duchan & Lund, 1979; Golinkoff, 1981; Howe, 1976, 1981, for discussion).

However, there has been ongoing debate within the field focusing on exactly how rich "rich interpretation" ought to be. If one of Bloom's subjects produced the sentence *mommy sock* while mother was putting on the child's sock, Bloom inferred that the child was conveying an agent-action-object relation, with the agent (mommy) and the object (sock) explicitly mentioned in the sentence and the action (put on) inferred from the nonlinguistic context. Bloom consequently was suggesting that at some underlying level the child could control three elements (mommy, put on, and sock), even though only two of those elements actually appeared in the surface form of the sentence.

Bloom mounted several different lines of evidence for her rich underlying structure claim. First, she found that the child is able to produce, at times, two-word utterances with all three of these types of elements: agent-action (*mommy push*), action-object (*helping mommy*), as well as agent-object (*mommy sock*). In fact, the child can produce all three elements in two consecutive (but still separate) utterances, such as *baby touch* (agent-action) *touch milk* (action-object), said when touching mother's milk glass. In addition, Bloom observed the child producing an occasional three-element utterance (agent-action-object, e.g., *baby touch milk*), suggesting that the child has control of all three elements at some underlying level, but cannot consistently produce these three elements in the surface forms of utterances. Finally, Bloom showed that the child's affirmative sentences are more likely to have fully expressed surface forms than are negative sentences, presumably because negative sentences have one more element in underlying structure (the negative marker) than do affirmative sentences. For example, the child would be more likely to say the agent in an affirmative utterance such as *Kathryn ə making house* than to say the agent in a negative utterance such as *no make a truck,* both utterances said while Kathryn was doing the building. Thus, Kathryn appears to have control of the agent at some underlying level—she can produce it when the number of elements in underlying structure (three in the previous affirmative sentence: agent, action, object) does not exceed her surface structure length limitation (three at this stage). But she fails to produce the agent when the number of elements in underlying structure (four in the negative sentence: agent, action, object, negative) goes beyond her three-word surface limitation.

Bloom's original underlying structure hypothesis entailed two claims, one which has been rejected by even Bloom herself, and a second which not only has not been refuted, but for which we find strong evidence in our data. The first claim attributed to the child a set of transformational rules (specifically, deletion rules), which transformed the child's rich underlying structure into more sparse surface structures. Under this hypothesis, in order for children to advance to the next stage of development, they had to *unlearn* this set of deletion rules—hardly a parsimonious description of development. Rather than attribute transformational rules to the young child, it is now generally accepted that the child has output constraints operating on speech-processing faculties (the most likely candidate being memorial limits), constraints which could lead naturally to omission in surface structure.

Bloom's second claim—the fact of surface structure omission in the young child's two-word sentences—although accepted by many, has not been hailed by all. For example, Brown (1973) maintains that children should be credited in underlying structure with no more than actually appears in their speech (i.e., that there is no underlying structure/surface structure distinction). The sentence *mommy sock* is described as a two-term agent-object relation, the sentence *put-on sock* as a *totally unrelated* two-term action-object relation. Brown thus attributes no more to children than they actually produce. But note that Brown's hypothesis, although seemingly more parsimonious than the underlying structure hypothesis, actually fails to account for a large number of facts about child language. In Brown's system, it is merely a coincidence that the child produces both *baby touch* and *touch milk*; moreover, it is only an accident that the child produces *baby milk* when "touch" is the understood action but fails to produce *baby milk* when, say, "sleep" is understood. Both facts are predicted by an underlying structure account that considers "touch" part of a three-term underlying structure and "sleep" part of a two-term underlying structure. Furthermore, although said to be a theory about development, Brown's hypothesis fails to account for the fact that, as children get older, they begin producing sentences like *baby touch milk* but fail to produce sentences like *baby sleep milk*. Thus, by not attributing a rich underlying structure to the young child's sentences, Brown will be forced to posit an additional set of rules or constraints to account for the sentences the two-word child does and does not produce and for the sentences the child will produce as he or she develops.

We have argued, relying on evidence comparable to Bloom's, that the deaf children in our studies also be credited with an underlying structure richer than the surface forms they actually produce. We find that the deaf children simultaneously produce gesture sentences that are two and three terms in length. For example, the child signs an occasional three-term sequence "food-EAT-Susan" (which we categorize as patient-act-actor) during the same developmental time period that he signs the two-term sequence "food-EAT" (which we categorize as patient-act with an inferred actor). Moreover, we also find situations in which the child first produces a sentence with two of the three terms hypothesized to be in the underlying structure of that sentence followed by another containing the omitted third term. For example, the child first signs the sentence "food-EAT" (patient-act) and immediately thereafter signs "EAT-Susan" (act-actor). Finally, we have distributional evidence based on the surface phenomenon of production probability for underlying structure in the deaf child's sentences: Givers (actors of four-element underlying structures) are less likely to be explicitly signed than eaters or goers (actors of three-element underlying structures), which in turn are less likely to be explicitly signed than dancers (actors of two-element underlying structures). It should be noted that evidence for at least some of these particular underlying structures can also be found in the hearing child's early two-word sentences (see Table 7.8, which provides actor, act, and patient production probability data on four hearing children from Bloom, Miller, & Hood, 1975, in our underlying structure format).[8]

In summarizing, it is important to note that Bloom's description of the child's two-word sentences in terms of underlying structures systematically related to surface structures, and Brown's (1973) description of these same sentences solely in terms of surface elements, *both* can adequately describe the particular two-word sentences the child actually produces. However, Bloom's description can also predict which particular semantic elements are likely to appear in the longer sentences children will produce during their next developmental stage. Brown's surface-oriented description will not. Moreover, and perhaps more importantly in terms of a synchronic grammatical description of the child's sentences, Bloom's description can account for the particular distributional facts found in the set of two-word sentences the child produces; in particular, her description can account for the production probability patterns in the hearing child data, patterns which we have found to characterize our deaf children's two-sign sentences as well. Again, Brown's description, taking only surface elements into account, fails to capture these facts. Thus, in order to account not only for the particular two-word sentences the child produces, but also for the relationships among those sentences (i.e., for the system which appears to underlie the sentences taken as a set), we are forced to describe both underlying and surface levels for the hearing child's two-word sentences and for the deaf child's two-sign sentences.

The need to posit an underlying structure for the young child's two-sign and two-word sentences is motivated in large part by the production probability patterns found across the deaf and hearing children's sentences. Several objections might be raised to the production probability data and to the arguments for underlying structure based on these data.[9] Below we review some of the more central objections to the production probability measure and its relation to the underlying structure argument.

[8] In Bloom, Miller, and Hood's (1975) terminology, sentences with four-elements underlying structure convey *agent-locative action-object-place* relations (comparable to our transfer relation); their sentences with three-element underlying structure convey *agent-action-object* relations (comparable to our transform relation) and *mover-locative action-place* and *patient-locative action-place* relations (comparable to our transport relation). Intransitive sentences (*agent-action*) which could have had two-element underlying structures (comparable to our perform relation) were not included in the analyses presented in Bloom et al. Our action is comparable to three different cases in Bloom et al., terminology: (1) Agent (in the four-element agent-locative action-object-place and in the three-element agent-action-object relations); (2) Mover (in the three-element mover-locative action-place relation); and (3) Patient (in the three-element patient-locative action-place relation). In addition, our Patient is comparable to their Object, and our Act comparable to their Action or Locative Action (labeled "Verb" in Bloom et al.'s tables).

TABLE 7.8
Underlying Structure in Simple Sentences with Two Spoken Elements Produced by Four Hearing Children[a]

	Actor Production Probability		Act Production Probability		Patient Production Probability	
Subjects	*4-element*	*3-element*	*4-element*	*3-element*	*4-element*	*3-element*
Gia	.24	.51	.78	.88	.68	.74
Peter	.10	.16	.82	.99	.55	.90
Eric	.32	.42	.87	.97	.52	.87
Kathryn	.14	.30	.83	.97	.89 √	.87

Note: The data for this analysis are from Bloom, Miller, Hood (1975); from Table 5 for Gia II through VI; Table 7 for Peter IV through IX; Table 4 for Eric II through VI; and Table 6 for Kathryn I through IV.

√ Violation of the underlying structure pattern.

[a] Production probability was calculated on the basis of the following number of sentences with two spoken elements: Gia for the actor and act 4-element 88, 3-element 456, and for the patient 88, 334; Peter for the actor and act 83, 401, and for the patient 83, 311; Eric for the actor and act 69, 400, and for the patient 69, 218; Kathryn for the actor and act 152, 656, and for the patient 152, 447.

[9] Brown (1978) has objected to the underlying structure hypothesis by arguing that the surface variation we find in the deaf child's sentences is totally attributable to a particular type of sentence—sentences in which I inferred "one" as the implicit actor or "(t)here" as the implicit recipient—a sentence type which he feels I have overinterpreted and which therefore should not be included in the data base at all. I have since reanalyzed the data, omitting all sentences of this type, and found the same surface phenomenon for all six children in the original study, as well as for the later sessions of the three children still accessible (Goldin-Meadow, 1980). Thus, the phenomenon under discussion does not appear to be an artifact of a particular sentence type.

Production Probability as a Measure of Underlying Structure

The first objection to the underlying structure argument concerns the production probability measure itself: It might be suggested that the production probability data we call upon to argue for underlying structure cannot fail to support the underlying structure hypothesis; that is, the analysis is tautological and production probability will unavoidably decrease as the number of elements hypothesized in underlying structure increases because of the procedure we use to calculate production probability. It is worth emphasizing that the argument we have mounted for underlying structure is not circular: Our procedure for calculating production probability does not prevent the unpredicted outcome (i.e., the procedure does not itself prevent production probability from increasing as the number of elements in underlying structure increases). For example, in describing a situation in which an actor gives a patient to a recipient, the child might (for reasons known best to him, e.g., salience) only produce sentences that contain patients (e.g., actor-patient, act-patient, recipient-patient). This hypothetical child would therefore be producing patients in 100% of his change-of-location transfer sentences, which are hypothesized to have four elements in underlying structure. Further, in describing a situation in which an actor eats a patient, the child might produce only actor-patient and act-patient sentences—the patient would therefore also occur in 100% of the child's change-of-state sentences, which are hypothesized to have three elements in underlying structure. Thus, in this not unreasonable hypothetical system, the eaten apple (the patient hypothesized as part of a three-element underlying structure) would be just as likely to be expressed as the given apple (the patient hypothesized as part of a four-element underlying structure). In the sign systems produced by each of the 10 children we have studied thus far, this situation is not observed.

A second set of objections to the underlying structure hypothesis might assume that the production probability pattern we observe is real, but would argue that this pattern could be explained more simply, relying on a description that credits children with no more in underlying structure than they explicitly produce in surface structure.

The Redundancy Hypothesis

It has been suggested (Brown, 1978) that the pattern of surface variation we observe in the deaf child's sign sentences can be accounted for by assuming simply that the child will fail to express explicitly that which is most obvious, or redundant, in the nonlinguistic situation. For example, in a request situation, the person who is being asked to be the actor is usually obvious from the nonlinguistic context. In contrast, the actor described in a statement is not as likely to be obvious from the nonlinguistic context. Thus, if actors are often

requested to transfer the location of objects or to change the state of objects (a not unlikely event in parent-child interactions), actors of transfer and transform relations might be infrequently expressed simply because they are redundant with the nonlinguistic context (and not because they are components of underlying structures with a large number of elements).

To test the possibility that the actor production probability pattern we observe reflects sentence functions and not underlying structure, I have divided the sign sentences produced by each of the four Chicago subjects into those making requests and those making statements or asking questions. Table 7.9 presents the same actor production probability data found in Table 7.3 for these four subjects divided into request and statement/question sentences. Although there do appear to be very few request sentences hypothesized to have two-element underlying structures, where the data do exist the production probability pattern observed previously can be seen for all children in request sentences and for three out of the four children for statement/question sentences. Even when the function of a sentence is held constant, actor production probability increases systematically as the number of elements hypothesized in underlying structure decreases. Thus, the surface structure variation we observe, which can be accounted for by an underlying structure hypothesis, cannot be accounted for by this particular application of the redundancy hypothesis.

Brown himself applied this redundancy hypothesis to our data by suggesting that first and second persons should be infrequently expressed because they are often obvious from the nonlinguistic context, whereas third persons should be frequently expressed because they are, in general, less obvious. Thus, first and second persons should have low production probabilities, whereas third persons should have relatively high production probabili-

TABLE 7.9
Underlying Structure in Request and Statement/Question Simple Sentences

	Actor Production Probability[a]					
	Request Sentences			*Statement/Question Sentences*		
	4-element	*3-element*	*2-element*	*4-element*	*3-element*	*2-element*
Mildred	.05	.67	–	.00	.00 √	1.00
Abe	.00	.40	–	.20	.42	1.00
Marvin	.00	.35	1.00	.00	.11	.67
Karen	.03	.20	–	.00	.50	.67

√ = Violation of the underlying structure pattern.

[a]Actor production probability was calculated on the following number of sentences with two signed elements: Mildred for requests 4-element 19, 3-element 9, 2-element 0, and for statement/questions 1, 16, 5; Abe for requests 29, 20, 0, and for statement/questions 5, 26, 1; Marvin for requests 27, 14, 2, and for statement/questions 12, 18, 3; Karen for requests 34, 10, 0, and for statement/questions 1, 14, 6.

ties regardless of relation type (i.e., regardless of the number of elements hypothesized in underlying structure). This version of the redundancy hypothesis is also not supported by our data. We have analyzed first, second, and third persons separately in the data from our original six subjects (see Table 7.10, which presents actor production probabilities in sentences with two signed elements). Although the number of sentences in certain cells is small, where the data are available it is clear that as the underlying structure hypothesis predicts, actor production probability varies systematically with the number of elements hypothesized in underlying structure for first, second, and third person actors. Thus, within each person category, production probability increases as the number of elements hypothesized in underlying structure decreases (see Goldin-Meadow, 1980, for further details). It is not the case that, as the redundancy hypothesis would have predicted, third person actors are likely to be signed regardless of relation type, nor does it appear to be true that first and second person actors are unlikely to be signed across all relation types. The underlying structure hypothesis consequently appears to explain surface structure variation in the deaf children's sign sentences more adequately than does the redundancy hypothesis.[10]

The Lexicalization Hypothesis

It might be suggested that the underlying structures hypothesized for the young children reflect their lexicalization of the aspects of the world they attend to (in particular, the aspects of the world that are salient for them; see Braine, 1974; Schlesinger, 1974). For example, the two-word child attends to four aspects of a change-of-location transfer situation—the actor, act, patient, and recipient—and, at any given time, lexicalizes the salient two of those four aspects. He or she attends to three aspects of a change-of-state situation—the actor, act, and patient—and, at any given time, lexicalizes the salient two of those three aspects. This lexicalization hypothesis essentially boils down to a restatement of the underlying structure hypothesis: Aspects

[10]Greenfield and Zukow (1978) propose the informativeness principle, a hypothesis similar to the redundancy hypothesis we have entertained, to account for variation in the particular semantic elements conveyed by the one-word speaker. They suggest, as does the redundancy hypothesis, that the child is more likely to express information which is situationally the least redundant. To account for the production probability data we have presented, the informativeness principle would have to predict that a semantic element, say, the patient, in a "giving" relation (a relation we hypothesize to have four elements in underlying structure) tends to be less informative in context than does the patient of an "eating" relation (hypothesized to have three elements in underlying structure). The child would then tend to produce signs for the less informative given apple less often than for the more informative eaten apple. Although possible, at present we have no evidence to suggest that the informativeness principle can account for the production probability phenomenon. However, it should be noted that perhaps some sort of informativeness principle might be able to account for the fact that actors in general tend to have lower production probabilities than do patients.

TABLE 7.10
Underlying Structure in Simple Sentences with 1st, 2nd, and 3rd Person Actors[a]

	Actor Production Probability[b]								
	1st Person Actors			2nd Person Actors			3rd Person Actors		
	4-element	*3-element*	*2-element*	*4-element*	*3-element*	*2-element*	*4-element*	*3-element*	*2-element*
David	.06	.43	1.00	.03	.46	—	.00	.51	.88
Donald	.00	.20	1.00	.06	.10	—	.00	.40	.88
Kathy	.00	.25	—	.06	.57	—	—	.50	1.00
Dennis, Tracy, and Chris	.00	.50	—	.03	.29	—	—	.50	1.00

[a]The data are from David sessions I-XIII, Donald I-XVI, Kathy I-XII, Dennis I-IV, Tracy I-II, and Chris I-III.
[b]Production probability was calculated on the following number of sentences with two signed elements: David for 1st person 4-element 18, 3-element 35, 2-element 3, for 2nd person 136, 48, 0, and for 3rd person 4, 70, 17; Donald for 1st person 2, 5, 1, for 2nd person 51, 10, 0, and for 3rd person 1, 25, 8; Kathy for 1st person 1, 4, 0, for 2nd person 31, 7, 0, and for 3rd person 0, 6, 5; Dennis, Tracy, and Chris for 1st person 5, 4, 0, for 2nd person 34, 14, 0, and for 3rd person 0, 8, 4.

of change-of-location situations are less likely to be lexicalized than aspects of change-of-state situations because there are four change-of-location aspects competing for lexicalization but only three change-of-state aspects.

The lexicalization hypothesis, however, does differ from the underlying structure hypothesis in one respect: Rather than call the four aspects of a change-of-location situation an "underlying structure," which the child is assumed to bring to the situation, the lexicalization hypothesis attributes the four-part structure to the situation itself. I find no persuasive reason to believe that a priori a change-of-location situation must be viewed as a four-part event. After all, the change-of-location event moves the object from a *source,* occurs in a *time* and *place,* and might even involve an *instrument* or a nonacting *observer*; each of these units could conceivably be considered integral to the change-of-location situation, making at least a five-part event. Or alternatively, perhaps for the young child, the actor transferring an object is not at all integral to the change-of-location situation; change-of-location would then be a three-part event. Cognitive psychologists have successfully demonstrated precisely this point: Events do not necessarily come packaged into irreducible units. Rather, we appear to interpret situations by imposing our own structures on them (e.g., the Piagetian liquid conservation situation is seen differently by a 5-year-old child and by an adult). Thus, the change-of-location situation itself does not *require* a four-part interpretation, and if we find (as we do) that the child interprets change-of-location as a four-part event, that interpretation cannot easily be attributed to the external situation.

In sum, our data suggest that children do interpret change-of-location transfer as a four-part event, an interpretative structure I suggest they themselves must bring to the transfer situation. Moreover, this four-element structure (along with the three- and two-element structures we have described) was found to influence the distributional patterns in the surface structures of the child's two-sign sentences and, in this sense, can be considered a rich structure that underlies those sentences.[11]

THE RESILIENCE OF LANGUAGE

Replication: Deaf Children of Hearing Parents

One purpose of this study was to replicate the phenomenon of gesture development on a second sample of deaf children. I have shown that the four deaf children in the Chicago sample developed gesture systems comparable in semantic content and structural properties (particularly, construction order patterns, production probability patterns, and rules of recursion) to the gesture systems developed by the six original deaf subjects in the Philadelphia sample. The ten deaf children we have observed over the course of our two studies share the two characteristics necessary for inclusion in the studies: (1) each child was congenitally deaf and unable to acquire spoken language naturally even with a hearing aid; (2) each child had not yet been exposed to a conventional sign language. Thus, all of the children in our studies experienced the same atypical language learning conditions, but none was prevented by these atypical conditions from developing a structured communication system.

Apart from their shared lack of conventional linguistic input, the ten deaf children varied on a number of sociological dimensions: race (two of our subjects were black, eight were white), socioeconomic status (two were lower class, eight were middle class), siblings (three had none, seven had at least one), number of parents in the home (two had one parent in the home for most or all of the study, eight had both parents), and educational setting (one did not start oral preschool until after our observations began, two attended the same oral preschool, three attended a second oral preschool, and four attended a different oral preschool). Despite this great variability, all ten of the children developed structured gesture systems.

The phenomenon of gesture development in deaf children lacking a conventional language model has been replicated by an independent investigator studying deaf children of hearing parents in Australia. Mohay (1982) completed a study comparable to ours of two deaf children, ranging in age from 1;6 to 2;6 and from 1;9 to 3;2, whose severe hearing losses prevented them from acquiring speech naturally and whose hearing parents chose not to expose them to conventional manual language. Mohay found that both of her deaf subjects used their gestures to convey the same semantic relations expressed by our deaf subjects and by hearing children at a similar stage of language development.

Moreover, Mohay found that both of her subjects combined gestures with other gestures, occasionally producing sequences three and four gestures long. In terms of structural properties, however, Mohay looked only at ordering tendencies of pointing gestures and found that points did not occupy privileged positions of occurrence in one of her subject's gesture sentences and that, although points occupied first position of the two-gesture sentences of her second subject up to 28 months (excluding point plus point sentences), on later tapes the point gesture ceased to occupy its privileged position.

In considering construction order in our subjects' gestures, we did not analyze our subjects' sign sentences at the level of *sign form* as did Mohay (i.e., in terms of deictic pointing forms). When such an analysis is performed, only three of our ten subjects are found to display ordering tendencies based on the deictic pointing form: Tracy (Binomial test, $p < .002$), Dennis (Binomial

[11] There remains a crucial question about whether the type of underlying structure we have described can be distinguished from the meaning of the sentence, from what we might call semantic structure. In simple one-proposition sentences there are no grounds for such a distinction. However, when complex, two-proposition sentences are considered, an argument can be made for an underlying structure distinct from semantic structure (see Goldin-Meadow, 1982).

Test, $p = .02$), and Mildred ($X^2 = 2.9$, $df = 1$, $p < .10$, trend) tended to produce deictic pointing signs in first position of their action sentences with one deictic and one characterizing sign. A comparable analysis for the hearing child's word sentences might presumably focus on the child's tendency to produce certain *word forms* before others (e.g., the tendency to produce nouns in first position of two-word sentences). Note that such ordering tendencies based on word form have not been reported for the hearing child. Thus, there is no particular reason to expect the deaf subjects (either ours or Mohay's) to display ordering tendencies based on the form of signs in their two-sign sentences.

However, for all of our deaf subjects we did find construction order tendencies in their two-sign sentences when these sentences were analyzed in terms of *semantic elements* (acts, patients, recipients, etc.). It is possible that Mohay would also find construction order tendencies in her subjects' sign sentences (as we did in ours and as researchers do in hearing children's spoken sentences) were she to analyze her data in terms of semantic elements.

The Resilient and Fragile Properties of Language

We have just seen that the phenomenon of gesture creation in deaf children of hearing parents is indeed replicable. Despite this robustness, we do not wish to claim that all deaf children of hearing parents will necessarily develop structured gesture systems. It is quite possible that certain types of deafness or certain types of social situations might prevent a child from communicating in a structured fashion. We have made no attempt to discover the internal and external limits of the child's propensity to develop structured language; that is, to determine which kinds of children under which kinds of circumstances will fail to exhibit this propensity.

Rather than explore the conditions that do not allow the child's language learning propensity to appear, our studies of deaf children of hearing parents have provided evidence that even under less-than-perfect language learning conditions, the child's propensity to develop language finds expression. We have shown that ten deaf children lacking conventional linguistic input can develop communication systems that have many of the structural properties of natural child language. I have called these properties of language "resilient." They are properties whose development can proceed under extreme variations in language learning conditions (Goldin-Meadow, 1978, 1982).

If the notion of resilient properties of language is to be of general value, it should predict that some set of properties of language will be developed in spite of extreme language learning conditions, whereas another set of properties of language (called "fragile") will tend not to appear. In fact, precisely those properties of language that do appear under linguistic hardship are the properties which must be called resilient. Those properties that do not appear must a priori be fragile. Each individual variation in the language learning

environment in effect sets up a kind of experiment of nature, allowing one to determine subsets of resilient and fragile language properties with respect to each particular language learning environmental manipulation.

A seminal study by Newport, Gleitman, and Gleitman (1977) on the effects and noneffects the relatively small variations in natural mother speech have on the rate of the hearing child's acquisition of English adds support to this notion of resilient and fragile properties of language. Newport et al. correlated mother speech at Time 1 with the changes in child speech from Time 1 to Time 2 and found the acquisition rate of properties we have called resilient (e.g., recursion) to be unaffected by (or insensitive to) variation in mother speech. The acquisition rate of properties we have called "fragile" (e.g., the auxiliary) was found to be correlated with (or sensitive to) variations in mother speech. Thus, resilient properties of language appear to be unaffected by variations in linguistic input (variations both large and small), whereas fragile properties of language appear to be quite sensitive to even relatively small variations in linguistic input.

The notion of resilient and fragile properties of language is further refined by the results of other studies of language learning under atypical conditions, some of which do explore the limits that external factors place on the child's propensity to develop structured language. For example, Brown (1958) in a review of the literature on children raised by wolves and bears reports that these wild children do not spontaneously begin to speak. Moreover, Curtiss (1977) has studied a modern-day "wild child," Genie, who was deprived of linguistic, social, and perceptual stimulation for the first 13 years of her life. During this time, Genie failed to develop any sort of communication system. Thus, there do appear to be limits to the human child's ability to develop even the resilient properties of language. The extreme environmental conditions of wild children such as Genie, not surprisingly, surpass those limits.

Although Genie did not generate her own communication system during her long period of isolation, when her social situation improved and she finally was exposed to spoken English (after the age of 13, the age often considered to be the end point of a critical period for language acquisition in humans, Lenneberg, 1967), she did make linguistic progress. However, Genie did not succeed in acquiring all of the properties of spoken English even after she was exposed to linguistic input. Rather, she acquired many of the same language properties we have found in the deaf child's spontaneous gesture systems (e.g., ordering rules, recursion); that is, she acquired some of the properties of language which we have called resilient. Thus, the development of some resilient properites of language not only appears to be resistant to wide (and small) variations in quality of linguistic input, but also appears to be resistant to wide variations in time of initial exposure to linguistic input.

Further, even after intervention, Genie failed to develop certain properties of English (e.g., the auxiliary, movement rules). These properties of language were also found to be absent from the deaf child's gesture system.

Thus, these properties do indeed appear to be fragile—properties of language whose development appears to require the conditions under which language is typically learned.

Sachs and her co-workers (Sachs, Bard, & Johnson, 1981; Sachs & Johnson, 1976) provide further evidence for resilient and fragile subsets of language properties in their studies of a hearing child, Jim, whose deaf parents exposed him neither to conventional oral nor to conventional manual linguistic input and who had heard English only from the television and briefly at nursery school. During his period of limited exposure to conventional language, Jim was found to develop many of the resilient properties of language (e.g., the expression and concatenation of semantic relations), but was not observed to develop the fragile properties (e.g., the auxiliary and certain movement rules). (After intervention at 3;9, Jim began to acquire the properties of English he lacked and went on to become a normal English speaker.)

It is particularly gratifying (but need not necessarily have been the case) that the subsets of resilient and fragile properties defined for one particular linguistic deprivation (our deaf children developing their communication systems without rich linguistic input) tend to coincide with the resilient and fragile subsets defined by other environmental manipulations (Genie developing English after age 13, Jim developing English with restricted linguistic input, and even language learning children facing the relatively small variations found in natural mother speech). An entire spectrum of severity of language learning deprivations might eventually be established in this manner, environments which would empirically define a spectrum of language properties running from the most resilient (developed virtually everywhere) to the most fragile (needing the most finely tuned support to find expression).

In sum, the study of the structured gesture systems developed by deaf children of hearing parents suggests that certain resilient properties of language can be developed even without the rich linguistic input children typically receive, but other fragile properties of language cannot. Moreover, data from other studies of language learning under atypical environmental conditions converge with our own, suggesting that resilient properties of language are those whose development is *resistant* to variations in time of initial exposure to linguistic input, as well as to variations in the richness of linguistic input. Conversely, fragile properties of language are those whose development is *sensitive* not only to variations in richness of linguistic input, but also to variations in time of initial language exposure. Thus, there appears to be a distinction in language properties based on the effects and noneffects of linguistic environments on the development of those properties: Resilient properties of language, resembling hardy weeds, crop up under even markedly atypical conditions, whereas fragile properties of language, more like hothouse orchids, flourish only in a restricted environmental range.

ACKNOWLEDGMENTS

I am most grateful to Lila Gleitman, Martha McClintock, Elissa Newport, William Meadow, and Carolyn Mylander for their particularly insightful comments on various versions of this manuscript. I thank Breckie Church, Ellen Eichen, Carolyn Mylander, Marolyn Morford, and Denise Unora for the many long hours of video tape transcription they have contributed to this study, and my subjects and their families for their continued cooperation. This work was supported by NSF Grant BNS 77-05990, by a grant from the Spencer Foundation, and by a Biomedical Sciences Support Grant PHS 5 507 PR-07029 to the University of Chicago.

REFERENCES

Bloom, L. *Language development: Form and function in emerging grammars.* Cambridge, Mass.: MIT Press, 1970.

Bloom, L. *One word at a time.* The Hague: Mouton, 1973.

Bloom, L., Capatides, J. B., & Tackeff, J. Further remarks on interpretive analysis in response to Christine Howe. *Journal of Child Language,* 1981, *8,* 403–412.

Bloom, L., Lightbown, P., & Hood, L. Structure and variation in child language. *Monographs of the Society for Research in Child Development,* 1975, *40*(2, Serial No. 160).

Bloom, L., Miller, P., & Hood, L. Variation and reduction as aspects of competence in language development. In A. Pick (Ed.), *The 1974 Minnesota Symposium on Child Psychology.* Minneapolis: University of Minnesota Press, 1975.

Bloomfield, L. *Language.* New York: Holt, 1933.

Bowerman, M. Semantic and syntactic development: A review of what, when and how in language acquisition. In R. Schiefelbusch (Ed.), *The bases of language intervention.* Baltimore: University Park Press, 1978.

Braine, M. The ontogeny of English phrase structure: The first phase. *Language,* 1963, *39,* 1–13.

Braine, M. Length constraints, reduction rules, and holophrastic processes in children's word combinations. *Journal of Verbal Learning and Verbal Behavior,* 1974, *13,* 448–456.

Braine, M. Children's first word combinations. *Monographs of the Society for Research in Child Development,* 1976, *41*(Serial No. 164).

Brown, R. *Words and things.* New York: The Free Press, 1958.

Brown, R. *A first language.* Cambridge, Mass.: Harvard University Press, 1973.

Brown, R. *It may not be Phrygian but it is not Ergative either.* Unpublished manuscript, Harvard University, 1978.

Brown, R., & Fraser, C. The acquisition of syntax. In C. N. Cofer & B. Musgrave (Eds.), *Verbal behavior and verbal learning: Problems and processes.* New York: McGraw-Hill, 1963.

Clark, E. How children describe time and order. In C. A. Ferguson & D. I. Slobin (Eds.). *Studies in child language development.* New York: Holt, Rinehart & Winston, 1973.

Curtiss, S. *Genie: A psycholinguistic study of a modern-day "wild-child."* New York: Academic Press, 1977.

Dixon, R. M. W. Ergativity. *Language,* 1979, *55*(1), 59–138.

Duchan, J., & Lund, N. J. Why not semantic relations? *Journal of Child Language,* 1979, *6,* 243–252.

El'konin, D. B. General course of development in the child of the grammatical structure of the

Russian language (according to A. N. Gvozdev). In C. A. Ferguson & D. I. Slobin (Eds.), *Studies in child language development*. New York: Holt, Rinehart & Winston, 1973.

Feldman, H., Goldin-Meadow, S., & Gleitman, L. Beyond Herodotus: The creation of language by linguistically deprived deaf children. In A. Lock (Ed.), *Action, symbol, and gesture: The emergence of language*. New York: Academic Press, 1978.

Fillmore, C. J. The case for case. In E. Bach & R. T. Harms (Eds.), *Universals of linguistic theory*. New York: Holt, Rinehart & Winton, 1968.

Frishberg, N. Arbitrariness and iconicity: Historical change in American Sign Language. *Language*, 1975, *51*(3), 696–719.

Goldin-Meadow, S. A study in human capacities. *Science*, 1978, *200*, 649–651.

Goldin-Meadow, S. Structure in a manual communication system developed without a conventional language model: Language without a helping hand. In H. Whitaker & H. A. Whitaker (Eds.), *Studies in neurolinguistics* (Vol. 4). New York: Academic Press, 1979.

Goldin-Meadow, S. *An unpragmatic view of underlying structure in child language*. Unpublished manuscript, University of Chicago, 1980.

Goldin-Meadow, S. The resilience of recursion: A study of a communication system developed without a conventional language model. In L. R. Gleitman & E. Wanner (Eds.), *Language acquisition: The state of the art*. New York: Cambridge University Press, 1982.

Goldin-Meadow, S., & Feldman, H. The development of language-like communication without a language model. *Science*, 1977, *197*, 401–403.

Goldin-Meadow, S., & Morford, M. Gesture in early child language: Studies of deaf and hearing children. To appear in *Merrill-Palmer Quarterly*, 1984.

Goldin-Meadow, S., & Mylander, C. Gestural communication in deaf children: The effects and non-effects of parental input on early language development. To appear in *Monographs of the Society for Research in Child Development*, 1984.

Goldin-Meadow, S., & Mylander, C. Gestural communication in deaf children: Noneffect of parental input on language development. *Science*, 1983, *221*, 372–374.

Golinkoff, R. M. The case for semantic relations: Evidence from the verbal and nonverbal domains. *Journal of Child Language*, 1981, *8*, 413–438.

Greenfield, P. M., & Zukow, P. G. Why do children say what they say when they say it? An experimental approach to the psychogenesis of presupposition. In K. Nelson (Ed.), *Children's language* (Vol. 1). New York: Gardner Press, 1978.

Harris, Z. S. *Methods in structural linguistics*. Chicago: University of Chicago Press, 1951.

Howe, C. The meanings of two-word utterances in the speech of young children. *Journal of Child Language*, 1976, *3*, 29–47.

Howe, C. Interpretive analysis and role semantics: A ten-year mesalliance? *Journal of Child Language*, 1981, *8*, 439–456.

Lenneberg, E. H. *Biological foundations of language*. New York: Wiley, 1967.

Limber, J. The genesis of complex sentences. In T. E. Moore (Ed.), *Cognitive development and the acquisition of language*. New York: Academic Press, 1973.

MacKay, D. M. Formal analysis of communicative processes. In R. A. Hinde (Ed.), *Non-verbal communication*. New York: Cambridge University Press, 1972.

Menyuk, P. *Sentences children use*. Cambridge, Mass.: MIT Press, 1969.

Menyuk, P. *The acquisition and development of language*. Englewood Cliffs, N.J.: Prentice-Hall, 1971.

Miller, W. R. The acquisition of grammatical rules by children. In C. A. Ferguson & D. I. Slobin (Eds.), *Studies of child language development*. New York: Holt, Rinehart & Winston, 1973.

Miller, W. R., & Ervin, S. The development of grammar in child language In U. Bellugi & R. Brown (Eds.), The acquisition of language. *Monographs of the Society for Research in Child Development*, 1964, *29*(Serial No. 92).

Mohay, H. A. A preliminary description of the communication systems evolved by two deaf children in the absense of a sign language model. *Sign Language Studies*, 1982, *34*, 73–90.

Newport, E. L., Gleitman, H., & Gleitman, L. Mother I'd rather do it myself: Some effects and non-effects of maternal speech style. In C. E. Snow & C. A. Ferguson (Eds.), *Talking to children: Language input and acquisition*. New York: Cambridge University Press, 1977.

Sachs, J., Bard, B., & Johnson, M. L. Language learning with restricted input: Case studies of two hearing children of deaf parents. *Applied Psycholinguistics*, 1981, *2*, 33–54.

Sachs, J., & Johnson, M. L. Language development in a hearing child of deaf parents. In W. von Raffler-Engel & Y. Lebrun (Eds.), *Baby talk and infant speech*. Lisse, Netherlands: Swets & Zeitlinger, 1976.

Schlesinger, I. M. Relational concepts underlying language. In R. L. Schiefelbusch & L. L. Lloyd (Eds.), *Language perspectives: Acquisition, retardation and intervention*. Baltimore: University Park Press, 1974.

Silverstein, M. Hierarchy of features and ergativity. In R. M. W. Dixon (Ed.), *Grammatical categories in Australian languages*. Canberra: Australian Institute of Aboriginal Studies, 1976.

Smith, C. S. An exprimental approach to children's linguistic competence. In J. R. Hayes (Ed.), *Cognition and the development of language*. New York: Wiley, 1970.

Stokoe, W. C. Sign language structure: An outline of the visual communications systems. *Studies in linguistics*, Occasional papers 1960, *8*, 3–78.