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3 Home Sign Systems in Deaf Children: The Development of Morphology without a Conventional Language Model

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3.1 Levels of Structure in Early Child Language: The Role of the Language Model

The language model a child is exposed to quite obviously affects the outcome of the language learning process. The young child learns English when exposed to English, Samoan when exposed to Samoan, American Sign Language when exposed to American Sign Language, and so on. It is possible, however, that properties of language differ in their sensitivity to the language model, and that even though the development of certain properties of language depends on the presence of a language model, the development of other properties does not. If so, a child who is exposed to no language model or to an impoverished language model might be expected to develop certain linguistic properties but not others. Sachs and her colleagues (Sachs, Bard, and Johnson 1981; Sachs and Johnson 1976) studied the language development of a hearing child exposed to an impoverished model of English by his deaf parents and found that the child developed some of the properties of English but failed to develop others. The child's dearth of linguistic input thus had differential effects on his language development, suggesting that a language model may not be equally essential for the development of all properties of language.

We have explored the importance of the language model to the development of various properties of language by observing children who are not exposed to a conventional model. The children we study are deaf, with hearing losses so severe that they cannot naturally acquire oral language. In addition, these children are born to hearing parents who have chosen not to expose them to a conventional sign language. We have shown that these children, despite their impoverished language learning conditions, develop a gestural communication system with some—but not all—of the properties of language found in the communication systems developed by young children learning language from conventional language models (Feldman, Goldin-Meadow, and Gleit-

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man 1978; Goldin-Meadow 1979, 1982; Goldin-Meadow and Feldman 1977; Goldin-Meadow and Mylander 1983, 1984). Our work has focused primarily on isolating those properties of language whose development can proceed without the guidance of a conventional language model—what we have called the "resilient" properties.

The heuristic we have adopted in describing the deaf children's gestural communication systems has been to determine which of the properties of early child language can be found in their gesture systems. Our previous work has demonstrated that the gesture systems our deaf subjects develop are comparable in many respects to early child language. In particular, the deaf children develop gestures that function as words do in the systems of hearing children learning conventional spoken languages and as signs do in the systems of deaf children learning conventional signed languages such as American Sign Language (ASL). The children in our studies produce two types of gestures: deictic signs used to refer to people, places, or things (e.g., a pointing sign at a snack), and characterizing signs used to refer to actions or attributes (e.g., a fist held at the mouth accompanied by chewing [EAT]).[1] In addition, the deaf children combine their signs into strings that function like the sentences of early child language in two respects: (1) The deaf children's sign sentences express the semantic relations typically found in early child language, with characterizing signs representing the predicates and deictic signs the arguments of those semantic relations. (2) The deaf children's sign sentences are structured like the sentences of early child language; specifically, there are order and deletion patterns identifiable across signs (or words) in a sentence (e.g., the sign for the patient role [snack] is likely to precede the sign for the act predicate [EAT]). Thus in our previous work we have found that deaf children, even without the benefit of a conventional linguistic model, can develop gestural communication systems with structural properties at the level of the sentence.

By age 3;6, however, children acquiring a conventional spoken language or a conventional sign language begin to develop structure at a second level—the level of the word or sign. Typically, children pass through an initial period during which they learn the words or signs of their language as unanalyzed wholes or "amalgams" (MacWhinney 1978; Newport 1984). During the next period they begin to learn that a word or sign can be composed of parts, each of which is meaningful. For example, initially a child might use the word "untie" appropriately but not be aware that the word is composed of two parts, "un" and "tie." Later, however, the child learns that "un" is a separable piece of the word associated with a particular meaning (to undo the result of an action), an insight reflected in an overgeneralized use of "un" (e.g., "unclothes" = to take the clothes off a baby; Bowerman 1982). At this stage the child gains productive control over the parts of words, knowing the parts themselves and how they combine to form words, and thus has structure not only at the level of the sentence but also at the level of the word.

1. Characterizing signs are represented in small capitals; for example, EAT represents a jabbing motion toward the mouth.

The purpose of this study is to determine whether the gesture systems created by our deaf subjects are structured at this second level, the level of the word or sign. We ask whether structure exists within signs as well as across signs and therefore whether a child can develop a system with structure at both the word/sign level and the sentence level without the benefit of a conventional language model. Thus our goal is to determine whether the deaf children in our studies display a hierarchy of structured levels in their gesture systems; in other words, we want to determine whether hierarchical structure is a "resilient" property of language.

3.1.1 Background on Deafness and Language Learning

Sign languages of the deaf are autonomous languages that are not derivative from the spoken languages of hearing cultures (Bellugi and Studdert-Kennedy 1980; Klima and Bellugi 1979; Lane and Grosjean 1980). A sign language such as ASL is a primary linguistic system passed down from one generation of deaf people to the next and is a language in the full sense of the word. Just as in spoken languages, ASL is structured at syntactic (Fischer 1975; Liddell 1980; Lillo-Martin and Klima 1990; Padden 1983), morphological (Fischer 1973b; Fischer and Gough 1978; Klima and Bellugi 1979; Newport 1981; Supalla 1982; Supalla and Newport 1978), and "phonological" (Battison 1974; Coulter 1990; Lane, Boyes-Braem, and Bellugi 1976; Liddell 1984; Liddell and Johnson 1989; Padden and Perlmutter 1987; Sandler 1986; Stokoe 1960; Wilbur 1986) levels of analysis.

Deaf children born to deaf parents and exposed from birth to a conventional sign language such as ASL have been found to acquire that language naturally; that is, in acquiring sign language these children progress through stages similar to those of hearing children acquiring a spoken language (Caselli 1983; Hoffmeister 1978; Hoffmeister and Wilbur 1980; Kantor 1982b; Newport and Ashbrook 1977; Newport and Meier 1986). Thus in an appropriate linguistic environment—in this case a signing environment—deaf children appear not to be handicapped with respect to language learning.

However, 90 percent of deaf children are not born to deaf parents who could provide early exposure to a conventional sign language. Rather, they are born to hearing parents who, quite naturally, tend to expose their children to speech (Hoffmeister and Wilbur 1980). Unfortunately, it is extremely uncommon for deaf children with severe to profound hearing losses to acquire the spoken language of their hearing parents naturally, that is, without intensive and specialized instruction. Even with instruction, deaf children's acquisition

of speech is markedly delayed compared with either the acquisition of speech by hearing children of hearing parents or the acquisition of sign by deaf children of deaf parents. By age 5 or 6, despite intensive early training programs, the average profoundly deaf child has only a very reduced oral linguistic capacity (Conrad 1979; Meadow 1968; Mindel and Vernon 1971). In addition, unless hearing parents send their deaf children to a school where sign language is taught, these children are not likely to be exposed to conventional sign input. In such unpropitious circumstances, these children might be expected to fail to communicate at all or perhaps to communicate only in nonsymbolic ways. This turns out not to be the case.

Previous studies of deaf children of hearing parents have shown that these children spontaneously use gestural symbols to communicate even if they are not exposed to a conventional sign language model (Fant 1972; Lenneberg 1964; Moores 1974; Tervoort 1961). These gestures are conventionally referred to as "home signs." Most of our previous work has focused on the structural aspects of deaf children's home signs, in particular on structure across signs in a sentence—structure at the "syntactic" level. In this chapter we focus on structure across components, called "morphemes," within a sign—structure at the "morphological" level. Our search for morphological structure in the deaf children's gesture systems is guided particularly by recent research on morphology in ASL. We begin by reviewing the findings of this literature that are relevant to our analyses.

3.1.2 Morphological Structure in ASL

Early research in ASL suggested that verbs in ASL, unlike verbs in spoken languages, appeared to be continually varying forms constructed on the basis of analogue representations of real-world events (DeMatteo 1977). In other words, ASL verbs were thought not to be divisible into component parts, but rather were considered unanalyzable lexical items that mapped, as wholes, onto events in the world. Subsequently, verbs in ASL (particularly the mimetic verbs of motion) have been more accurately described as combinations of a limited set of discrete morphemes (McDonald 1982; Newport 1981; Supalla 1982).

For example, to describe a drunk's weaving walk down a path, an ASL signer would not represent the idiosyncrasies of that drunk's particular meanderings but would instead use a conventional morpheme representing random movement (a side-to-side motion) in conjunction with a conventional morpheme representing change of location. Mimetic verbs in ASL have been shown to be constructed from discrete sets of morphemes and to include, at a minimum, a motion morpheme combined with a handshape morpheme (McDonald 1982; Newport 1981; Supalla 1982).

Morphemes in ASL (as in spoken languages) have been organized into

frameworks or matrices of oppositions, referred to as "paradigms" (cf. Matthews 1974). For example, the motion for "linear path" (representing change of location along a straight path) can be combined with any number of handshapes representing agents or actors (e.g., inverted V = a human; a bent inverted V = an animate nonhuman; thumb + two fingers held sideways = a vehicle). These combinations create a set of signs whose meanings are predictable from the meanings of the individual motion and handshape elements (a human moves along a straight path, an animate nonhuman moves along a straight path, a vehicle moves along a straight path). In another example, a different motion form (e.g., "arc path," representing change of location along an arced path, such as jump forward) can be combined with any of these same handshape morphemes to create a set of signs whose meanings are also systematic combinations of the component parts of each sign (e.g., a human jumps foward, an animate nonhuman jumps forward, a vehicle jumps forward). Thus many of the verbs of ASL can be described in terms of a combination of handshape and motion morphemes that together form complete paradigmatic sets.

3.2 Morphology in Home Signs: Structure within the Sign

To determine whether our deaf subjects' signs can also be characterized by systematic combinations of meaningful forms, we selected one of our original subjects (David) and analyzed the characterizing signs (the mimetic signs) he produced in naturalistic play sessions videotaped in his home when he was aged 2;10, 2;11, 3;0, 3;3, 3;5, 3;11, and 4;10.[2] These ages span the age range during which both deaf (Supalla 1982) and hearing (MacWhinney 1976) children learning conventional languages have typically already begun to acquire certain morphemic distinctions.

The videotapes of David were coded initially at the sign level according to a system described in detail in Goldin-Meadow (1979) and Goldin-Meadow and Mylander (1984).[3] We then coded each characterizing sign produced during

2. Two of the types of characterizing signs David produced during these videotapes are omitted from the analyses presented here and will be described in a forthcoming report; (1) 243 signs that were conventional in that they occur in the spontaneous gestures accompanying the speech of hearing adults and children in our culture (e.g., a flat hand extended palm up to mean "give," or two fists held together and then rotated away from each other to mean "broken"); and (2) 68 signs in which the motion sign traces the extent or outline of an object.

3. In our previous analyses of sentence-level structure in the deaf children's gestures, we glossed all characterizing signs as predicates, assigning act predicate meanings to signs that mirrored the actions on or by objects (e.g., EAT) and assigning attribute predicate meanings to signs that mirrored the perceptual characteristics of objects (e.g., ROUND; see Goldin-Meadow and Mylander 1984, 23–26, for the rationale behind these coding decisions). For the present analysis, we code the meaning of each sign twice: (1) We first code the sign in terms of the characteristics of the object that the sign is used to refer to (either the object involved in the actions of act predicates

these sessions in terms of its handshape and motion. Reliability between two independent coders ranged from 85 percent to 95 percent for handshape and from 83 percent to 93 percent for motion.

To determine whether the deaf child's signs were divisible into handshape and motion morphemes, we reviewed David's entire corpus of characterizing signs and asked whether the set of signs met the following three criteria for structure at the morphological level:

1. Is there a limited set of discrete handshape and motion forms in the child's corpus of signs? That is, are the forms categorical rather than continuous?
2. Is a particular handshape or motion form consistently associated with a particular meaning (or set of meanings) throughout the corpus of signs? That is, is each handshape and motion form meaningful?
3. Does a particular handshape or motion form/meaning pairing appear in more than one sign? That is, is a particular form/meaning pairing an independent morpheme that can combine with other morphemes in the system? Is the system combinatorial?

We begin by analyzing the forms and meanings of the handshapes David used in his signs and then the forms and meanings of the motions in those signs. We next describe the combinations of handshapes and motions that occurred in the corpus of David's signs. Finally, we focus on how those handshape/motion combinations David developed changed over the two-year period spanned by this study.

3.2.1 Handshape Morphemes

Handshape Forms

Following Supalla (1982) and McDonald (1982), we coded each handshape according to four dimensions: the shape of the palm, the distance between the fingers and the thumb, the number of fingers extended, and the presence or absence of spread between the fingers. At first we coded handshapes continuously along each dimension without establishing a priori either discrete categories or boundaries. Thus, for example, we wrote down the exact distance (in inches) between the fingers and thumb of a particular handshape and did not try to force that handshape into a limited set of thumb-finger distances. We found, however, that David used only a restricted number of values on each of the four dimensions. Table 3.1 displays the five most frequent handshapes David used on these tapes, described in terms of the relevant dimensions. These five handshapes accounted for 98 percent of all of the handshapes David produced ($N = 473$).

The remaining 2 percent of David's handshapes not represented in table 3.1 were: V (two fingers spread apart and extended), L (thumb and forefinger extended at right angles to each other), thumb (thumb extended), F (thumb and finger touching with the other three fingers extended in the "okay" sign), and W (three fingers spread apart and extended). Each of these infrequently produced handshapes was used to represent only one object throughout the tapes (e.g., the V was used to represent scissors, the L was used to represent a gun). We saw no evidence that these handshapes participated in a generative way in David's sign system, so we eliminated them from further analyses.

Handshape Form/Meaning Mapping

We next determined whether David's handshapes mapped in any systematic way onto categories of meanings. We found that David used his handshapes in two ways: to represent a HAND as it manipulates an object, or to represent the OBJECT itself. For example, to describe a picture of a knife, David produced a fist handshape (with a back-and-forth movement), which mirrors a cutter's hand manipulating a knife and thus is an instance of a HAND handshape. In contrast, to describe the same picture of the knife, in a separate sentence David produced a palm handshape held perpendicular to the table (with the

Table 3.1 Description of Handshape Forms

Handshape Form	Description
Fist	Fingers and thumb curled into palm
O	Index finger or four fingers bent toward thumb with one-half inch or less between thumb and finger(s)[a]
C	Index finger or four fingers bent toward thumb with three inches between thumb and finger(s)[a]
Palm	Four fingers extended
Point	Index finger extended

[a] If only the index finger was bent toward the thumb in the O and C handshapes, the other three fingers were either curled into the palm or held sloppily in an untensed manner.

or the object described in attribute predicates). We take this object information to be relevant to the meanings of handshape forms (cf. table 3.2). (2) We also code the sign in terms of the characteristics of the action the sign is used to refer to (the action in act predicates), and we take this information to be relevant to the meaning of motion forms (cf. table 3.4). All attribute signs were, by definition, produced without motion. We arbitrarily assigned the meaning "exists" or "is" as a placeholder for the no-motion component of these signs in the morphological analysis in table 3.4. The absence of motion in attribute signs may, of course, be meaningless. If so, attribute signs would be glossed only in terms of the object characteristics they portray (e.g., ROUND, CURVED, BULKY) and would therefore be included in table 3.2 (handshape meanings) but not table 3.4 (motion meanings).

same back-and-forth movement), mirroring the flat shape of the knife itself and therefore meeting the criterion for an OBJECT handshape. The same handshape could be used with either a HAND or an OBJECT meaning in David's system. For example, David used a C handshape to describe a cup where the handshape mirrored a hand grasping the diameter of the cup [HAND], and (rotated ninety degrees) to describe a turtle where the handshape mirrored the curved back of the turtle [OBJECT].

To determine the meaning of each handshape form, we first listed all the objects represented by each handshape form used with either a HAND or an OBJECT meaning in the one-motion signs (signs that contained only a single motion) David produced during one session, the session at age 3;11. We then determined whether the set of objects associated with a particular handshape form could be said to share a common attribute or set of attributes. If so, we took that common core to be the meaning of the particular handshape form. We then used these form/meaning pairings to code the videotapes of the six remaining sessions.

Table 3.2 describes the meanings found to be associated with the HAND and OBJECT handshape forms in the session at age 3;11, as well as examples of the objects represented by each handshape form/meaning pairing. Table 3.2 also presents the total number of different types of objects represented by each form/meaning pairing and, in parentheses, the total number of times each form/meaning pairing was used throughout the seven videotaped sessions.[4] We found that 368 (95 percent) of the 387 handshapes David produced in his one-motion signs during the seven videotaped sessions could be classified into the form/meaning categories listed in table 3.2. In addition, sixty-eight (91 percent) of the seventy-five handshapes in David's two-motion signs (signs that contained two motions concatenated without a break so that both appeared to be within the same sign) were also found to conform to the form/meaning categories established on the basis of the one-motion signs produced during the 3;11 session. Note that the palm and point handshapes were each used to represent more than one class of objects (e.g., the OBJECT palm was used to represent [1] flat, wide objects, [2] many small particles, and [3] vehicles and animate objects); each of these classes is considered a distinct morpheme. Exceptions to table 3.2 consisted of form/meaning mismatches, such as a fist form used to represent a small, *short* (rather than a long) object (e.g., a knob on a toy), or a palm form used to represent a round inanimate object (e.g., a ball moving forward).

4. Numbers reported for handshape (table 3.2) reflect signs in which handshape was codable regardless of whether the corresponding motion could be seen and coded. Similarly, numbers reported for motion (table 3.4) reflect signs in which motion was codable, again independent of whether the corresponding handshape could be coded. Numbers reported for handshape and motion combinations (tables 3.5 and 3.6) reflect signs in which both handshape and motion were codable.

Table 3.2 Meanings of Handshape Forms

	HAND Morphemes		OBJECT Morphemes	
Form	Meaning	Types (tokens)	Meaning	Types (tokens)
Fist	Handle small, long object (e.g., spoon, drumstick, balloon string, handlebar)[a]	19 (70)	Bulky object (hammerhead, block)	2 (3)
O	Handle small object (e.g., crank, shoelace)[a]	31 (102)	Round compact object (e.g., round hat, tree ball, bubble)	6 (17)
C	Handle large object (e.g., cup, horn, guitar neck)[a]	11 (20)	Curved object (e.g., cowboy's legs around a horse, turtle)	5 (7)
Palm	Handle flat surface (e.g., sides of toy bag, chair back)	12 (30)	Flat wide object (e.g., fish, flag, bird wings)	9 (43)
			Many small particles (e.g., snow)	6 (9)
	Handle many small surfaces (xylophone keys)	1 (3)	Vehicle or animate object (e.g., car, sister, Santa, plane)	13 (26)
Point	Handle small surface (trigger)	1 (2)	Thin straight object (e.g., straw, bubble wand, pinwheel)	6 (12)
			Object of any shape (e.g., bear, penny, Susan)	13 (24)

Note: The table contains the handshapes found in David's one-motion signs during the seven videotaped sessions. The first number represents the different types of objects represented by the handshape, and the number in parentheses represents the total times the handshape was used for that meaning.
[a]Small = two inches or less in diameter; large = more than two inches in diameter; long = more than five inches in length.

It is important to note that David's HAND morphemes were not always accurate representations of the way a hand grasps a particular object in the real world, nor were his OBJECT morphemes precise mimetic reconstructions of real-world objects. For example, the same HAND form (the fist) was used to represent grasping a balloon string, a drumstick, and handlebars—grasping actions that require considerable variety in diameter in the real world. David therefore appeared not to distinguish objects of varying diameters within the fist category. However, he did distinguish objects with small diameters *as a set* from objects with large diameters (e.g., a cup, a guitar neck, the length of a straw), which were represented by a C hand.

As another example, David used the same OBJECT form (the O) to represent a round hat, a Christmas tree ball, and a bubble—objects that vary in width in the real world. David again did not appear to distinguish objects with varying widths within the O category, but rather appeared to categorize them all as small round objects. However, David did distinguish these small, round objects *as a set* from larger curved objects (e.g., a turtle's back, a cowboy's legs around a horse), which were represented by a C hand. Overall, David thus appeared to consign handshapes to discrete categories rather than to utilize analogue representations of "real-world" objects.

3.2.2 Motion Morphemes

Motion Forms

We found that David used eight different types of motions, as well as a no-motion form, in his signs (table 3.3). The motions were defined in terms of the type of trajectory traced by the hand (linear path, arced path, circle) or the motions of the hand in place (revolve, open/close, bend, wiggle). In addition, arcs were distinguished in terms of length of path (seven inches or less vs. more than seven inches) and directionality (unidirectional vs. bidirectional). These motion forms account for 100 percent of the signs David produced during these sessions ($N = 514$).

Motion Form/Meaning Mapping

To determine whether each of David's nine motion forms was associated with a particular class of meanings, we began by listing all the actions David represented with each of the nine motion forms in the one-motion signs he produced during the session at age 3;11. We then determined whether the actions associated with a particular motion form shared certain common attributes. If so, we took that common core to be the meaning of the particular

Table 3.3 Description of Motion Forms

Motion Form	Description
Linear	Hand moves in a straight path
Long arc	Hand moves unidirectionally in an arced path more than seven inches in length
Short arc	Hand moves unidirectionally in an arced path seven inches or less in length
Arc to and fro	Hand moves bidirectionally in an arced path of any length
Circular	Hand moves in circle; wrist or fingers revolve
Open/close	Hand or fingers open and/or close
Bend	Hand or fingers bend
Wiggle	Fingers wiggle
No motion	Hand held in place

Table 3.4 Meanings of Motion Forms

Type of Motion	Form	Meaning	Types (tokens)
Change of location	Linear	Change of location by moving along a path	16 (34)
	Long arc	Change of location by moving along a path, typically to or from a particular end point	19 (24)
Change of position	Short arc	Reposition (or reorient) in place; reposition to affect another object; or reposition with respect to another object or place	33 (71)
	Arc to and fro	Reposition by moving back and forth	29 (114)
	Circular	Reposition by moving in a circle or rotating around an axis	15 (37)
Change of shape	Open/close	Open/close, expand/contract, or flicker on/off	9 (16)
	Bend	Bend at a joint	2 (5)
	Wiggle	Wiggle back and forth	2 (3)
No change	No motion	Hold in place or exist	29 (91)

Note: The table contains the motions found in David's one-motion signs during the seven videotaped sessions. The first number represents the different types of actions represented by the motion, and the number in parentheses represents the total times the motion was used for that meaning.

motion form and used the resulting set of form/meaning pairings to code the videotapes from the remaining six sessions.

Table 3.4 presents the meanings of the motion forms David produced in his one-motion signs during the session at age 3;11, as well as the total number of different types of actions represented by each form/meaning pairing (and, in parentheses, the total number of times each motion form/meaning pairing was used) over the course of the seven videotaped sessions.

We found that David used his motion forms to represent four types of change in the state of an object: change of location, change of position, change of shape, and no change. He used the linear and long arc forms to represent *change of location* along a path, either of an object (or a person) moving on its own (that is, an intransitive motion; e.g., bubble go up, we go down) or an object being moved by a person (transitive motion; e.g., move coat, scoop spoon). Although both forms were used to represent change of location, the long arc was typically used to represent a change of location bounded by a particular end point (e.g., penny arc forward [toward a bank]), while the path represented by the linear form could be either open ended (e.g., bubble go upward), or bounded by an end point (e.g., we go down [to the bottom of the stairs]).

David used the arc to and fro, circular, and short arc forms to represent the *change of position* either of an object (or a person) repositioning itself (that is, an intransitive motion; e.g., wheel tip over), or an object being repositioned

by a person (a transitive motion; e.g., turn over clay). A change of position involved bidirectional repositioning around a center point (the arc to and fro form; e.g., wings flap, jiggle handlebars side to side), unidirectional repositioning around an axis or center point (the circular form; e.g., wheel rotate, turn crank), or unidirectional repositioning having no center point (the short arc form). There were three types of meanings conveyed by the short arc form: repositioning in the same spot (e.g., wheel tip over), repositioning an object to affect another object (e.g., swing hammer [to knock tower], shake envelope [to release contents]), or repositioning an object with respect to another object or a place, either to remove the object (e.g., pick up bubble jar [off table]) or to place the object (e.g., hook tree lights [onto Christmas tree], push down box lid [onto bottom of box]).

David used the open/close, bend, and wiggle forms to represent the *change of shape* either of an object altering its own form (an intransitive motion; e.g., bubble expands, fish bends [to swim]), or a hand altering its shape on an object (a transitive motion, e.g., hand closes [around toy bulb], fingers wiggle [to strike piano keys]). The open/close form was used to represent an object (or hand) opening or closing (e.g., claw closes), expanding or contracting (e.g., bubble expands), or flicking on and off (e.g., tree lights flicker). The bend form was used to represent an object bending at a joint (e.g., fish bends). The wiggle form was used to represent an object (or hand) wiggling (e.g., snow flutters).

Finally, David used the no-motion form to represent *no change* in an object as it is held in place (e.g., hold bubble wand [at mouth]) or as it exists (e.g., puzzle board exists, bubble exists).

We found that 395 (90 percent) of the 439 motions in the one-motion signs David produced during the seven videotaped sessions could be classified according to the form/meaning pairings listed in table 3.4. In addition, 69 (92 percent) of the 75 motions in David's two-motion signs conformed to the form/meaning pairings established on the basis of the one-motion signs produced during the session at age 3;11. Exceptions to table 3.4 consisted of form/meaning mismatches, such as a short arc form used to represent the path of a change of location (e.g., a turtle moving forward along a path), or a long arc form used to represent an object repositioning itself (e.g., a wheel tipping over in place).

3.2.3 *Handshape and Motion Combinations*

We have shown that David's signs can be described in terms of handshape morphemes (handshape form/meaning pairings) and motion morphemes (motion form/meaning pairings). We now attempt to demonstrate that the signs themselves were in fact composites of hand and motion morphemes rather than one unanalyzed whole—that is, that handshape and motion are separable

units. Since signs are composed of hands moving in space, it is not possible to find handshapes that are actually separated from their motions. Nevertheless, if we find a handshape that is not uniquely associated with one sign but rather is combined with several different motions in different signs, we then have evidence that the handshape may be an independent unit in David's system. Similarly, if a motion is combined with different handshapes in different signs, we infer evidence for the separability of that motion. We will consider first David's HAND handshape morphemes in combination with motion morphemes and then David's OBJECT handshape morphemes in combination with motion morphemes.

HAND Handshape Morphemes Combined with Motion Morphemes

Table 3.5 displays the number of types of events represented by each pairing of a HAND handshape with one of the nine motions; the numbers in parentheses represent the total number of times a particular handshape occurred with a particular motion. The table contains David's one-motion signs, excluding those that were exceptions to either table 3.2 (handshape form/meaning pairings) or table 3.4 (motion form/meaning pairings). In table 3.5 the handshapes represent an actor's hand shaped on or around a patient, and the motions represent events in which an actor manipulates a patient (transitive events).

Table 3.5 HAND Handshapes Used in Combination with Motions

	Fist	O	C	Palm (flat surface)	Palm (many surfaces)
Change of location					
Linear	—	—	—	1 (1)	—
Long arc	1 (1)	1 (1)	—	1 (2)	—
Change of position					
Short arc	6 (12)	10 (20)	2 (2)	2 (5)	—
Arc to and fro	7 (28)	7 (42)	1 (1)	5 (8)	1 (1)
Circular	1 (1)	5 (8)	4 (10)	—	—
Change of shape					
Open/close	1 (1)	2 (2)	—	—	—
Bend	—	—	—	—	—
Wiggle	—	—	—	—	1 (2)
No change					
No motion	6 (16)	9 (24)	3 (6)	—	—

Note: The first number in each entry represents the different *types* of events represented by the handshape/motion combination. The number in parentheses represents the total times the handshape/motion combination was used—the number of *tokens*. Only one-motion signs are included in the table. The point morpheme (meaning handle a small surface) is not included, since it did not occur with any well-formed motions.

Four of the six HAND handshapes occurred with at least four and as many as six of the nine motions; the two exceptions were the palm (many surfaces) morpheme and the point morpheme (not shown in table 3.5). The palm (many surfaces) morpheme occurred with only two motions, and the point morphemes did not occur with any well-formed motion morphemes. Moreover, six of the nine motions occurred with at least two and as many as five of the six HAND handshapes; the three exceptions were the linear morpheme and the wiggle morphemes, which were each used to represent a single event, and the bend morpheme, which was not used at all with HAND handshapes. Thus, most of the handshape morphemes could be found in combination with more than one motion morpheme, and vice versa. As a result, David's signs can be said to conform to a framework or system of contrasts. As an example of how the meanings of David's signs systematically contrasted with one another, the fist handshape was used in combination with the short arc motion to mean "change the position of a small, long object by hand" (e.g., pull out newspaper). The same fist handshape used in combination with a different motion (the arc to and fro) meant "move a small, long object to and fro by hand" (e.g., wave balloon string back and forth), while the same short arc motion used in combination with a different handshape (the C) meant "change the position of a large object by hand" (e.g., pick up bubble jar).

OBJECT Handshape Morphemes Combined with Motion Morphemes

Table 3.6 displays the number of types of events represented by each pairing of an OBJECT handshape with one of the nine motions; the numbers in parentheses represent the total number of times a particular handshape occurred with a particular motion. The table contains David's one-motion signs, again excluding the exceptions to tables 3.2 and 3.4. Three types of signs are contained in table 3.6: (1) signs describing an (intransitive) event in which an actor (animate or inanimate) propels itself and does not affect a patient, where the handshape represents a characteristic of the actor—for example, a C handshape used with a linear motion to describe a turtle moving forward; (2) signs describing a (transitive) event in which an actor affects a patient, where the handshape represents a characteristic of the patient—for example, a C handshape used with a short arc motion to describe the curved shape of a cowboy's legs as someone places the cowboy on a horse;[5] and (3) signs describing a static object—for example, a C handshape used with a no-motion

5. The orientation of the hand with respect to the motion was crucial in identifying OBJECT handshapes with transitive motions. In the example presented in the text, the fingers and palm of the C handshape point downward as the short arc motion descends, mirroring the shape of the cowboy's legs as they go around the horse. If, however, the C were perpendicular to the short arc motion (oriented as a person's hand would be if it were placing the cowboy on the horse), the handshape would be considered a HAND handshape and the sign would be included in table 3.5.

Table 3.6 OBJECT Handshapes Used in Combination with Motions

	Fist	O	C	Palm Flat Wide	Palm Vehicle Animate	Palm Particles	Point Straight Skinny	Point Neutral
Change of location								
Linear	—	—	2 (3)	1 (1)	9 (13)	—	1 (2)	3 (7)
Long arc	—	—	1 (1)	1 (1)	4 (4)	1 (1)	2 (2)	5 (7)
Change of position								
Short arc	2 (3)	2 (3)	1 (2)	1 (1)	4 (4)	1 (1)	—	3 (3)
Arc to and fro	—	1 (1)	—	5 (18)	—	—	—	—
Circular	—	—	—	—	—	—	—	2 (3)
Change of shape								
Open/close	—	—	1 (1)	1 (1)	—	2 (4)	—	—
Bend	—	—	—	1 (2)	1 (3)	—	—	—
Wiggle	—	—	—	—	—	1 (1)	—	—
No change								
No motion	—	6 (11)	1 (1)	4 (18)	—	1 (1)	3 (5)	—

Note: The first number in each entry represents the different *types* of events represented by the handshape/motion combination. The number in parentheses represents the total times the handshape/motion combination was used—the number of *tokens*. Only one-motion signs are included in the table.

form to describe the arced shape of a block. Table 3.6 contains seventy-two (56 percent) signs of type 1 (OBJECT handshapes with intransitive motions), twenty-six (20 percent) signs of type 2 (OBJECT handshapes with transitive motions), and thirty-one (24 percent) signs of type 3 (OBJECT handshapes with no motion).

Seven of the eight OBJECT handshapes occurred with at least three and as many as seven of the nine motions; the exception was the fist handshape. Similarly, seven of the nine motions occurred with at least two and as many as seven of the eight handshapes; the exceptions were the circular and wiggle motions. Thus David's signs containing OBJECT handshapes combined with motions also appeared to fit into a framework or system of contrasts. As an example of how the meanings of these signs contrasted systematically with one another, the palm (vehicle/animate) handshape was combined with the linear motion to mean "a vehicle or animate being changes location" (e.g., Santa goes down; car goes forward). This same handshape when combined with a different motion (the short arc) meant "a vehicle or animate being repositions itself" (e.g., sister sits), while the same linear motion when combined with a different handshape (the C) meant "a curved object changes location" (e.g., a turtle moves forward). The handshape morphemes in David's signs thus formed a relatively complete matrix or paradigm with the motion morphemes in the corpus of signs.[6]

3.2.4 The Development of Signs

Thus far we have suggested that a child without the benefit of a conventional language model can develop a system of signs comprising handshape and motion morphemes. We now consider the developmental steps that such a child might have taken in arriving at a handshape/motion system of contrasts.

David appeared to develop his lexicon by recruiting gestures from the actions of people and objects around him, presumably with an eye to adequately representing particular objects and events. We hypothesize that David first developed his lexical items by focusing only on the relationship between the form of the sign and the event it represented. Later, perhaps when he had accumulated a sufficient number of signs in his lexicon, David may have begun to consider his signs in relation to one another and may have organized them around any regularities that appeared in his lexicon. For example, small, long objects tend to be held by a fist—not always, but perhaps often enough so that fistlike handshapes might have predominated in the signs David created to represent handling small, long objects. He might then have made use of this trend in his lexicon and organized his system of contrasts around it.

6. As mentioned above, David also combined motions with other motions. Approximately 10 percent of the signs David produced during these seven sessions contained two or more motions. The two-motion signs are described in detail in Goldin-Meadow and Mylander, 1991.

If this hypothesis is correct, we would expect that, early on, each sign in David's repertoire might represent a single referent rather than a class of referents. For example, he might use the C handshape in combination with a circular motion to refer only to twisting a bubble jar lid and the C handshape in combination with a short arc motion to refer only to repositioning a cup. If so, each handshape/motion combination in those early sessions would be used to represent only one type of event.

After initially generating each sign in his system to map onto a particular event as a whole, David might later "analyze" his set of wholes into handshape and motion components that map onto classes of objects and actions, respectively. We would then expect that the C + circular combination, for example, would be used not only to mean "twist the bubble jar lid" but also to mean "rotate the large knob" or "move the large toy in a circle"; that is, the sign would be used to refer to a class of objects (objects with large diameters) and a class of actions (rotating or moving objects around a center point). If David were to follow this developmental path, we would expect that many of the handshape/motion combinations in his later videotaped sessions would be used to represent classes of related events rather than single events.

Table 3.7 presents the number of handshape/motion combinations used to represent a single event or a class of events for each of the seven videotaped sessions. The data are presented separately for HAND and OBJECT handshapes. Note that David used six different HAND handshape/motion combinations during the first session (age 2;10). However, each of those six combinations was used to describe a single event. It was not until the second session (age 2;11) that David first used one HAND handshape/motion combination to represent a class of events. The number of handshape/motion combinations representing classes of events subsequently increased to nine (at age 3;11). It is important to note that the appearance of handshape/motion combinations representing

Table 3.7 Number of Handshape/Motion Combinations Used to Represent a Single Event or a Class of Events at Each Age

	HAND Handshape/Motion Combinations		OBJECT Handshape/Motion Combinations	
Age (years; months)	Representing a Single Event	Representing a Class of Events	Representing a Single Event	Representing a Class of Events
2; 10	6	—	2	—
2; 11	3	1	3	—
3; 0	1	—	1	—
3; 3	5	1	6	3
3; 5	4	5	5	—
3; 11	7	9	20	6
4; 10	7	5	9	5

classes of events in the early sessions was *not* attributable to a general increase in the total number of signs David produced—he produced more HAND handshape/motion combinations during the first session (seventeen signs at age 2;10) than he did during the second and fourth sessions (eleven signs at age 2;11 and twelve signs at age 3;3).

With respect to David's OBJECT handshapes, a comparable developmental pattern was observed. When David first produced OBJECT handshape/motion combinations, each of those combinations was used to represent a single event. Subsequently, at age 3;3, David used three OBJECT handshape/motion combinations to represent classes of events, and by 3;11 he was using six of these signs to represent classes of events. Thus the developmental pattern seen in both the HAND and OBJECT handshapes is consistent with the hypothesis that David's signs are initially unrelated, unanalyzed wholes that are later organized in relation to one another to form a system of contrasts.

3.3 The Role of the Child and the Environment in the Development of Morphological Structure

3.3.1 The Resilience of Morphological Analysis

We have found that the corpus of signs David produced can be characterized as a system of handshape and motion morphemes; in particular, David's signs were composed of a limited and discrete set of five handshapes and nine motion forms, each consistently associated with a distinct meaning and recurring across different signs. David's signs therefore appeared to be decomposable into smaller morphemelike components, suggesting that his gesture system was indeed structured at the sign level. Moreover, these structured characterizing signs formed the building blocks for the sentences he produced. David frequently used his characterizing signs in multigesture sentences, in combination both with deictic (pointing) signs and with other characterizing signs. For example, in a sample of six videotapes taken between the ages of 2;10 and 3;8, 49 percent of the 482 characterizing signs David produced were found to occur with other signs in sentence combinations. Thus his characterizing signs, which were themselves structured at one level, formed the fundamental units for structure at a second (higher) level, suggesting that the sign system was indeed characterized by hierarchical structure.

It is important to note that David's signs did not always reflect referents in the real world as transparently as they might have. The signs were often more abstract and symbolic than a pantomime of a real-world object or action would require and, as such, were not constrained by a tight fit between a sign and the object or action it represented. For example, though in the manual modality one can in principle represent shapes and movements along a continuous dimension, David used discrete (noncontinuous) forms to represent objects and

actions in his signs (e.g., he used the same handshape to represent holding a thin balloon string and a thicker steering wheel). When representing an object, David appeared to choose among the limited number of handshapes available in his system rather than shaping his hand to match precisely his actual grip on the object. At some level he seemed to be sacrificing the fit between a sign and its referent in order to achieve categorical representation (e.g., David used a fist handshape to represent holding a banana even though bananas require a wider hand grip). Thus, like ASL, David's gesture system does not take advantage of the possibility of continuous and transparent representation afforded by the manual modality and instead appears to be based upon categorical representation, as are all conventional languages.

In addition, as in all conventional languages, David appeared to organize his representational categories into a framework or system of contrasts. When David generated a sign to refer to a particular object or action, the form of that sign was determined not only by the properties of the referent object or action, but also by how that sign fit with the other signs in his lexicon. For example, David's motion form long arc, meaning change of location, contrasted with his motion form short arc, which meant change of position. Moreover, when the long arc was combined with a fist (meaning to handle a small, long object), the meaning of the composite sign could be derived from the meanings of the individual motion and handshape forms (i.e., change the location of a small, long object by hand) and also differed systematically from the meaning of a short arc + fist combination (which meant change the position of a small, long object by hand).

Finally, the developmental course of David's signs appears to be comparable to the development of words or signs in children acquiring conventional languages. When first generating signs, David seems to have created each sign to map onto a particular event, a stage reminiscent of the period during which children acquiring conventional languages treat their words or signs as unanalyzed wholes (MacWhinney 1978; Newport 1984). Later in development David began to use a single sign to refer to a class of events—events that involved actions sharing a common attribute (represented by the motion component of the sign) and objects sharing a common attribute (represented by the handshape component of the sign). At this point, then, David's system can be described in terms of components of sign forms mapping onto components of sign meanings, rather than the whole sign form mapping onto a global, particular event. This latter stage is comparable to the period when children acquiring conventional languages begin to analyze the words they have learned as wholes into meaningful components (Bowerman 1982; MacWhinney 1978; Newport 1984).

Our findings suggest that at some point in developing a communication system, children can begin a process akin to morphological analysis on the codes

they are creating—even if they are provided with no explicit model for such analysis. Thus, despite the absence of a conventional language model, a child can develop a communication system that has morphological structure, suggesting that morphological structure is itself a "resilient" property of language.

Evidence from other studies of language learning support the notion that children impose morphological structure onto the language system they are developing even if structure of this sort is not in the language model they are receiving. For example, in spoken language, children who are exposed to pidgin languages that tend not to have morphology (structure within the word) have been found to creolize the language and in the process develop a system that has morphological structure (Kay and Sankoff 1974; Sankoff and Laberge 1973). As a second example, in sign language deaf children are often born to deaf parents who learned ASL late in life. Some of these late-learning adults develop sign systems that lack much of the morphological complexity of ASL (Newport 1984). Nevertheless, deaf children learning ASL from parents with incomplete morphological systems go on to develop sign systems with morphological structure; indeed, their morphological systems are indistinguishable from those developed by deaf children learning ASL from parents with complete morphological systems (Newport 1984).

3.3.2 The Role of the Language Model in Morphological Analysis

The corpus of signs David produced can be characterized as a system of handshape and motion morphemes. This system is comparable in broad outline to the handshape and motion system that underlies ASL. Not surprisingly, however, the system of subsign components David developed is not as complex as the morphological system underlying ASL, a conventional language that has a rich linguistic history and is shared by a wide community of signers.

Comparison with Motion Morphemes in ASL

David used nine motion forms in his signs, a set reminiscent of that isolated by Newport (1981) and Supalla (1982) in their descriptions of motion in ASL. Moreover, the meanings of David's nine motion forms fall into the same four broad categories as do the motion meanings attributed to the signs of ASL, although the details of the motion meanings differ.

First, David used two forms (linear and long arc) to represent change of location along *any* path. In ASL the type of path is specified within the change-of-location morpheme: linear path means move along a straight path, arc path means move in an arc or jump (Supalla 1982). Thus the change-of-location morphemes in ASL are more specified than the comparable morphemes in David's system.

Second, David represented change of position with three forms, short arc (= repositioning an object), arc to and fro (= change position by moving back and forth), and circular (= move in a circular path or rotate). In ASL, two forms represent change of position or orientation: end pivot means swing, and midpivot means rotate (Supalla 1982). A third ASL form, circular path, which means move in a circle, partially overlaps in meaning with David's circular form but is listed by Supalla as a change of location, not a change of orientation.

Third, David used three forms to represent change of shape (open/close, bend, and wiggle). ASL has four forms that differ in detail from David's: spread, bend-flat, bend-round, and change-diameter, each of which reflects a change in the attributes of an object (Supalla 1982).

Finally, David used his no-motion form to represent the existence of an object or holding an object in place. In ASL a distinction is made between the existence and location of an object, and that distinction is conveyed through motion: a hold movement means existence, and minimal contacting movement means location (Supalla 1982).

Comparison with Handshape Morphemes in ASL

The five predominant handshapes in David's system represent the unmarked handshapes of adult ASL systems (cf. Klima and Bellugi 1979) and are the same handshapes produced by young deaf children learning ASL from their deaf parents during their initial stages of acquisition (McIntire 1977). Since David used only the unmarked and none of the marked handshapes of ASL, he used fewer handshapes overall than are found in ASL, even in the ASL produced by young children. Nevertheless, David's use of handshapes to represent objects closely parallels the way handshapes are used in ASL.

David's handshapes represented objects in three ways. First, a set of David's OBJECT handshapes represented the visual-geometric characteristics of an object: Fist (bulky object), O (round, compact object), C (curved object), palm (flat, wide object), palm (many small particles), and point (thin, straight object). In ASL, handshapes (called size and shape specifiers; cf. Supalla 1982) are also used to represent the visual-geometric properties of an object, but the set of handshapes available in ASL is much larger than David's set. Moreover, the visual-geometric handshapes in ASL themselves consist of a group of simultaneous hand-part morphemes rather than a single handshape morpheme (Supalla 1982). For example, the number of fingers extended represents the width or depth of an object (one finger = thin or flat; two fingers = narrow or shallow; four fingers = wide or deep), while the curvature of the palm represents the shape of an object (palm straight = straight object; palm curved = round object). These components are combined within a sign in ASL to represent the width/depth *and* shape of an object (e.g., one straight

finger = thin and straight object; one curved finger = flat and round object, etc.). At present we have no evidence that David's handshapes themselves consisted of a number of simultaneous morphemes rather than a single morpheme.

Second, David used one of his OBJECT handshapes to represent a semantic subcategory of objects: palm (vehicle or animate object), that is, a self-propelling object. In ASL this same category is represented, but with many more distinctions. For example, ASL has separate handshapes to represent a human, a small animal, a wheeled vehicle, an airplane, and a boat (Supalla 1982).

Finally, David's HAND handshapes represented an object indirectly by reflecting the hand grip used to manipulate the object: fist (handle a small, long object), O (handle a small object), C (handle a large object), palm (handle a large, flat surface), palm (handle many small surfaces). Again, ASL has a set of handshapes that are used in comparable ways but with many more distinctions (e.g., thumb and finger touching, with the other three fingers extended and spread = handle a wide, flattish-bottomed object; flat palm with the fingers spread = handle a flat plane; McDonald 1982).

Interestingly, when deaf children acquire ASL from their deaf parents, they tend at the earliest stages to use some handshapes comparable in form and meaning to David's. Supalla (1982) studied the development of size and shape and semantic classifiers in verbs of motion and location in three deaf children of deaf parents (ranging in age from 3;6 to 5;11). He found that all three children used what Supalla called "primitive" handshapes, the palm and the point. Two used the point for any category (as David did in his OBJECT point = any object), while the third used the point for wide, flat, and cylindrical objects. All three used the palm for animals, vehicles, and airplanes (as did David), and one used the palm for wide, flat, and cylindrical objects as well. Thus, even if provided with a conventional language model, children tend to use the same simple forms for the same general categories as David did. However, it is important to point out that, even by age 3;6, the children in Supalla's study were correctly producing the more specified handshapes for humans, animals, vehicles, and airplanes on a substantial number of the stimuli—handshapes and distinctions not seen in David's signs as late as age 4;10.

The similarities at a broad level between handshapes and motions in ASL and handshapes and motions in David's system suggest that David's set of handshapes and motions may reflect the units that are "natural" to a visual/manual language—units that may form part of the basic framework not only for ASL morphology but also for the morphologies of other sign languages. An examination of the early stages of acquisition of sign languages other than ASL might shed light on this issue, as would observations of spontaneous sign systems developed by deaf children in other cultures without access to a conventional sign language.

The deaf child in our study lacked a model of ASL—in particular, a model for the signs of ASL—which could have provided "guidance" in the extraction of subsign units. Without such "guidance," David acquired a system of subsign units with far less complexity than the morphological system of ASL. Thus, if a child like David is not exposed to a conventional language model, he is able to take only small steps toward developing a morphological system. In contrast, deaf children exposed to some model of ASL—even if that model lacks morphological analysis—have been found to develop the morphological system of ASL in *all* its complexity (Newport 1984). As might be expected, therefore, even an impoverished language model seems to make a significant difference in the nature of the morphological system the child develops.

The linguistic environment a child is exposed to thus appears to play a role in the complexity of the morphological system the child induces. Nevertheless, the fact that David could fashion a morphological system—albeit a simple one—even without the benefit of conventional linguistic input suggests that some aspects of linguistic analysis may be strongly guided by internal factors. At the very least these data suggest that, with or without a language model, children seek structure at the morphological level when developing systems for communication.

In sum, our previous work has shown that without the guidance of a conventional language model a child can develop a gesture system that has structure at the syntactic level—the level of the sentence. We report here that this same gesture system is also structured at the morphological level—the level of the word. Moreover, the forms and uses of morphological components in our subject were in several respects comparable to the forms and uses of morphological components as described for deaf children learning a conventional sign language (ASL). We suggest that hierarchical structure (or at least two hierarchical levels) appears to be a resilient property of language—a property whose development can withstand a dramatic alteration of the conditions children typically experience when learning to communicate.