The Resilience of Language

Susan Goldin-Meadow
The University of Chicago

1. What Gesture Creation in Deaf Children Can Tell Us About How All Children Learn Language

Children learn the language to which they are exposed. They not only graciously accept whatever differences are found across languages, but they learn those differences early. The consequence, of course, is that we see the effect of linguistic input at the earliest stages of language-learning. But just because children are influenced by their linguistic input very early in development does not mean that they come to language-learning without biases about language. It does mean, however, that it is going to be very difficult, if not impossible, to discover whatever biases children do have about language by looking at language-learning in typical circumstances. To discover the biases that children themselves bring to language-learning, we need to turn to language development in unusual circumstances – to children who are not exposed to linguistic input.

But when is a child not exposed to linguistic input? My colleagues and I have for three decades been studying children who lack access to usable linguistic input. The children had profound hearing losses and were unable to master spoken language even with intensive oral instruction. Moreover, they were born to hearing parents who did not know sign language and, at the time of our observations, had not exposed their children to sign language. As a result, the children did not have usable input from a conventional language. Under such circumstances, we might expect children to fail to communicate at all or, if they do make their needs and wants known, to do so through non-symbolic means.

But that's not what the children did. They used their hands to communicate – they gestured – and those gestures took on many of the forms and functions of natural languages. Because the children in our studies were not exposed to usable input from a conventional language, the gestures that they created must have been shaped, not by a linguistic system handed down from generation to generation, but by their own predispositions about how to communicate. The gestures therefore display the biases that children themselves bring to language-learning – what I have called the "resilient properties of language" (Goldin-Meadow, 1982, 2003a).

I begin by giving a brief overview of the linguistic properties found in the deaf children's gesture systems. I then focus on a subset of these properties and explore the implications of finding them in the deaf children's gesture systems for language-learning in all children. Although the deaf children we study are not exposed to a usable model of a conventional language, they are surrounded by hearing speakers who gesture when they talk. An important question then is whether the resilient properties of language are also found in the gestures of

 BUCLD 27 Proceedings, ed. Barbara Beachley et al., 1-25. Somerville, MA: Cascadilla Press.

hearing speakers. If so, the driving force behind these properties may come from adults who already know a language, rather than from deaf children who do not. We will find that the resilient properties of language do *not* arise in the gestures that hearing speakers produce and the question then is "why not?" In the final section, I explore the conditions that permit gesture to become language.

Table 1 lists the properties of language that we have found in the deaf children's gesture systems – the resilient properties of language. There may, of course, be many others – the list is limited by the properties that we have looked for and succeeded in finding. The table lists properties at the word- and sentence-levels, as well as properties of language use.

Table 1. The Resilient Properties of Language

Words	Sentences	Language Use
Stability	Underlying Predicate Frames	Here-and-Now Talk
Paradigms	Deletion	Displaced Talk
Categories	Word Order	Generics
Arbitrariness	Inflections	Narrative
Grammatical Functions	Recursion	Self-Talk
	Redundancy Reduction	Metalanguage

1.1. Words

The deaf children's gesture words have five properties that are found in all natural languages. The gestures are *stable* in form, although they needn't be (Goldin-Meadow, Butcher, Mylander & Dodge, 1994). It would be easy for the children to make up a new gesture to fit every new situation. Indeed, this appears to be just what hearing speakers do when they gesture along with their speech (McNeill, 1992). But that's not what the deaf children do. They develop a stable store of forms which they use in a range of situations – they develop a lexicon, an essential component of all languages.

Moreover, the gestures they develop are composed of parts that form *paradigms*, or systems of contrasts (Goldin-Meadow, Mylander & Butcher, 1995). When the children invent a gesture form, they do so with two goals in mind – the form must not only capture the meaning they intend (a gesture-to-world relation), but it must also contrast in a systematic way with other forms in their repertoire (a gesture-to-gesture relation). In addition, the parts that form these paradigms are *categorical*. The manual modality can easily support a system of analog representation, with hands and motions reflecting precisely the positions and trajectories used to act on objects in the real world. But, again, the children don't choose this route. They develop categories of meanings that, although essentially iconic, have hints of *arbitrariness* about them (the children don't, for example, all share the same form-meaning pairings for handshapes).

Finally, the gestures the children develop are differentiated by *grammatical function*. Some serve as nouns, some as verbs, some as adjectives (Goldin-Meadow et al., 1994). As in natural languages, when the same gesture is used for more than one grammatical function, that gesture is marked (morphologically and syntactically) according to the function it plays in the particular sentence.

1.2. Sentences

The deaf children's gesture sentences have six properties found in all natural languages. Underlying each sentence is a *predicate frame* that determines how many arguments can appear along with the verb in the surface structure of that sentence (Feldman, Goldin-Meadow & Gleitman, 1978; Goldin-Meadow, 1985). Indeed, according to Bickerton (1998), having predicate frames is what distinguishes language from its evolutionary precursor, protolanguage.

Moreover, the arguments of each sentence are marked according to the thematic role they play. There are three types of markings that are resilient (Goldin-Meadow & Mylander, 1984, 1998):

- *deletion* – the children consistently produce and delete gestures for arguments as a function of thematic role;
- *word order* – the children consistently order gestures for arguments as a function of thematic role; and
- *inflection* – the children mark with inflections gestures for arguments as a function of thematic role.

In addition, *recursion*, which gives natural languages their generative capacity, is a resilient property of language (Goldin-Meadow, 1982). The children form complex gesture sentences out of simple ones. They combine the predicate frames underlying each simple sentence, following systematic, and language-like, principles. When there are semantic elements that appear in both propositions of a complex sentence, the children have a systematic way of *reducing redundancy*, as do all natural languages (Goldin-Meadow, 1987).

1.3. Language Use

The deaf children use their gestures for many of the central functions that all natural languages serve. They use gesture to make requests, comments, and queries about things and events that are happening in the situation – that is, to communicate about the *here-and-now*. Importantly, however, they also use their gestures to communicate about the non-present – *displaced* objects and events that take place in the past, the future, or in a hypothetical world (Butcher, Mylander & Goldin-Meadow, 1991; Morford & Goldin-Meadow, 1997).

In addition to these rather obvious functions that language serves, the children use their gestures to make category-broad statements about objects, particularly about natural kinds – to make *generic* statements (Goldin-Meadow, Gelman & Mylander, 2003). They use their gestures to tell stories about themselves and others – to *narrate* (Phillips, Goldin-Meadow & Miller, 2001). They use their gestures to communicate with themselves – to *self-talk*. And finally, they use their gestures to refer to their own or to others' gestures – for *metalinguistic* purposes.

The resilient properties of language listed in Table 1 are found in all natural languages, and in the gesture systems spontaneously generated by deaf children. But, interestingly, they are *not* found in the communication systems of non-humans. Even chimpanzees who have been explicitly taught a communication system by humans do not display the array of properties seen in Table 1. In fact, a skill as simple as communicating about the non-present seems to be beyond the non-human primate. For example, Kanzi, the Shakespeare of language-learning bonobos, uses his symbols to make requests 96% of the time (Greenfield & Savage-Rumbaugh, 1991) – he very rarely comments on the here-and-now, let alone the distant past or future. The linguistic properties displayed in Table 1 are resilient in humans, but not in any other species – indeed, there are *no* conditions under which other species will develop this set of properties.

The deaf children do not develop all of the properties found in natural languages. We call the properties that the deaf children don't develop the "fragile" properties of language. For example, the deaf children have not developed a system for marking tense. The only property that comes close is the narrative marker that some of the children use to signal stories (essentially a "once upon a time" marker). But these markers are lexical, not grammatical, and don't form a system for indicating the timing of an event relative to the act of speaking. As a second more subtle example, the deaf children do not organize their gesture systems around a principle branching direction. They show neither a bias toward a right-branching nor a left-branching organization, unlike children learning conventional languages who display the bias of the language to which they are exposed (Goldin-Meadow, 1987).

We are, of course, on more shaky ground when we speculate about the fragile properties of language than the resilient ones. Just because we haven't found a particular property in the deaf children's gesture systems doesn't mean it's not there (and it doesn't mean that the children won't develop the property later in development). The negative evidence that we have for the fragile properties of language can never be as persuasive as the positive evidence that firmly supports the resilient properties of language. Nevertheless, the data from the deaf children can lead to hypotheses about the fragile properties of language that can then be confirmed in other paradigms.

2. Sentence Level Structure

2.1. Underlying Predicate Frames

Sentences are organized around verbs. The verb conveys the action which determines the thematic roles or arguments (θ-roles, Chomsky, 1982) that underlie the sentence. For example, if the verb is "give" in English or "donner" in French, the framework underlying the sentence contains three arguments – the giver (actor), the given (patient), and the givee (recipient). In contrast, if the verb is "eat" or "manger," the framework underlying the sentence contains two arguments – the eater (actor) and the eaten (patient). Do frameworks of this sort underlie the deaf children's gesture sentences?

We have studied gesture sentences in 10 deaf children of hearing parents in America (Philadelphia and Chicago) and 4 in China (Taipei, Taiwan). All of the deaf children produce sentences about transferring objects and, at one time or another, they produce gestures for each of the three arguments that we would expect to underlie such a predicate. They almost never produce all three arguments in a single sentence but, across all of their sentences, they produce a selection of two-gesture combinations that, taken together, displays all three of the arguments. For example, David produces the following two-gesture sentences to describe different events in which a person transfers an object to another person. In the first three, he is asking his sister to give him a cookie. In the fourth, he is asking his sister to give a toy duck to me so that I will wind it to make it go (pointing gestures are in lower case, iconic gestures in capitals). By overtly expressing the actor, patient, and recipient in this predicate context, David is exhibiting knowledge that these three arguments are associated with a transfer-object predicate.

(1) a. cookie – GIVE (patient – act)
    b. sister – David (actor – recipient)
    c. GIVE – David (act – recipient)
    d. duck – Susan (patient – recipient)

The children also produce sentences about acting on objects without changing their location. Again, they produce gestures for each of the two arguments that we would expect to underlie such a predicate. For example, Karen produces the following two-gesture sentences to describe different events in which a person acts on an object. In the first two, she is asking me to twist open the bubble jar for her. In the third, she is saying that she herself will twist open the jar. By overtly expressing the actor and patient in this predicate context, Karen is exhibiting knowledge that these two arguments are associated with the an act-on-object predicate.

(2) a. bubbles – TWIST (patient – act)
    b. Susan – bubbles (actor – patient)
    c. TWIST – Karen (act – actor)

The children also produce sentences about actions that do not involve objects. For example, Abe produces the following gesture sentences to describe different events in which an object or person moves on its own to a new location (or, in my terms, recipient). In the first, Abe is saying that he will go outside. In the second, he is saying that the penny will go to the slot on the toy bank after he pulls a trigger which propels the penny forward. In the third, which actually contains three gestures, he is asking his friend to go to the candle on a nearby birthday cake. By overtly expressing the actor and recipient in this predicate context, Abe is exhibiing knowledge that these two arguments are associated with the move-to-location predicate.

(3) a. outside – Abe (recipient – actor)
    b. GO – slot (act – recipient)
    c. candle – friend – GO (recipient – actor – act)

Finally, Tracy produces the following two-gesture sentence to describe a picture of an octopus wriggling in place. By overtly expressing the actor with these predicates, she is exhibiting knowledge that this argument is associated with the perform-in-place predicate.

(4) octopus – WRIGGLE (actor – act)

Most of the children's sentences that convey a single proposition contain only two gestures (like hearing children learning a language such as Inuktitut who continue to produce short sentences as they develop simply because their language permits a great deal of deletion). As a result, the deaf children rarely produce all of the arguments that belong to a predicate in a single sentence. What then makes us think that the entire predicate frame underlies a sentence? Is there evidence, for example, that the recipient and actor arguments underlie the sentence "cookie give" even though the patient "cookie" and the act "give" are the only elements that appear in the surface structure of the sentence? Yes. The evidence comes from how likely the child is to produce gestures for various arguments – what we have called "production probability".

Production probability is the likelihood that an argument will be gestured when it can be. The children cannot produce gestures for all of the arguments that belong to a 2- or 3-argument predicate in their two-gesture sentences – they are not yet capable of producing sentences that long. Counting the predicate, there are 3 candidate units for the two slots in a sentence with a 2-argument predicate frame (actor, patient, act; or actor, recipient, act), and 4 candidate units for the two slots in a sentence with a 3-argument predicate frame (actor, patient, recipient, act). The children must therefore leave some arguments out of their gesture sentences. They could leave elements out haphazardly – but they don't. They are quite systematic in how often they omit and produce gestures for various arguments in different predicate frames. This is just the pattern we would expect if the predicate frame is the organizing force behind a sentence.

Take the actor as an example. If we are correct in attributing predicate frames to the deaf children's gesture sentences, a *giver* (i.e., the actor in a "give" predicate) should be gestured *less* often than an *eater* (the actor in an "eat" predicate) simply because there is more competition for slots in a 3-argument "give" predicate (4 units in the underlying predicate frame) than in a 2-argument "eat" predicate (3 units in the underlying predicate frame). The *giver* has to compete with the *act,* the *given* and the *givee*. The *eater* has to compete only with the *act* and the *eaten*. This is precisely the pattern we find. Figure 1 presents production probability for actors in two-gesture sentences that have predicate frames of differing sizes. Both the American and Chinese deaf children are *less* likely to produce an actor in a sentence with a 3-argument underlying predicate frame (e.g., the *giver*, white bars) than an actor in a sentence with a 2-argument underlying predicate frame (e.g., the *eater*, hatched bars).

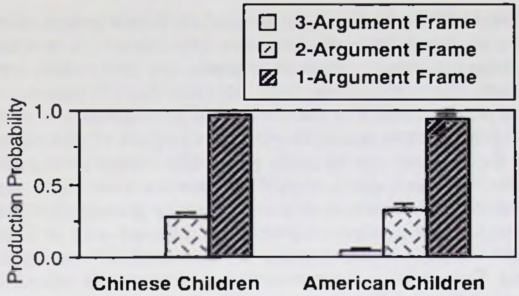

Figure 1. The Production of Gestures for Semantic Elements in a Sentence Depends on the Predicate Frame Underlying that Sentence. The figure displays the likelihood that the Chinese and American deaf children will produce a gesture for an actor in a 2-gesture sentence as a function of the predicate frame underlying that sentence. Children are more likely to produce actors in sentences with a 1-argument than a 2-argument predicate frame, and in sentences with 2-argument than a 3-argument predicate frame, simply because there is less "competition" for the two slots in surface structure when the underlying frame contains fewer units and thus offers fewer candidates for those slots. Errors bars reflect standard errors.

Following the same logic, an *eater* should be gestured *less* often than a *dancer* (the actor in a "dance" predicate) because there is more competition for slots in a 2-argument "eat" predicate (3 units in the underlying predicate frame) than in a 2-argument "dance" predicate (2 units in the underlying predicate frame). The *eater* has to compete with the *act* and the *eaten*, but the *dancer* has no competition at all since the predicate frame has only two slots, one for the *act* and one for the *dancer*. We see this pattern in Figure 1 as well. The children are *less* likely to produce an actor in a sentence with a 2-argument underlying predicate frame (e.g., the *eater*, hatched bars) than an actor in a sentence with a 1-argument underlying predicate frame (e.g., the *dancer*, black bars). Actor production probability is not 100% for sentences with 1-argument predicate frames simply because the children occasionally produced gestures for non-essential elements rather than for the actor (e.g., the "place" where the action is taking place, a non-essential but allowable element in any action sentence).

In general, what we see in Figure 1 is that production probability *decreases* systematically as the number of arguments in the underlying predicate frame *increases* from 1 to 2 to 3 (and it does so for each of the children, see Goldin-Meadow, 2003a, for data on the individual children). Importantly, we see the same pattern for patients: The children are *less* likely to produce a gesture for a *given* apple than for an *eaten* apple simply because there is more competition for slots in a 3-argument "give" predicate (4 units in the underlying predicate frame) than in a 2-argument "eat" predicate (3 units in the underlying predicate frame; Goldin-Meadow, 1985).

It is worth making one final point – it is the underlying predicate frame that dictates actor production probability in the deaf children's gesture sentences, not how easy it is to guess from context who the actor of a sentence is. We convinced ourselves of this by examining production probability separately for 1st person actors (i.e., the child him or herself), 2nd person actors (the communication partner), and 3rd person actors. If predictability in context is the key, 1st and 2nd person actors should be omitted regardless of underlying predicate frame because their identity can be easily guessed in context (both persons are on the scene); and 3rd person actors should be gestured quite often regardless of underlying predicate frame because they are less easily guessed from context. We found, however, that the production probability patterns seen in Figure 1 hold for 1st, 2nd, and 3rd person actors when each is analyzed separately (Goldin-Meadow, 1985). The predicate frame underlying a sentence is indeed an essential factor in determining how often an actor will be gestured in that sentence.

This is an important result. Tomasello (2000) suggests that the process of learning predicate frames is completely data-driven – that children learn from linguistic input which arguments are associated with a verb on a verb-by-verb basis. The implicit assumption is that, without linguistic input, children would not organize their verbs around predicate frames. But our data suggest otherwise. Children seem to come to language-learning with at least some predicate frames in mind. They expect, for example, symbols referring to transferring objects to be associated with 3 arguments (actors, patients, recipients) and symbols referring to acting on objects to be associated with 2 arguments (actors, patients). All a child learning English need do is figure out that "put" is a verb of the first kind, and "eat" is a verb of the second kind. Rather than requiring linguistic input for their construction, these "starter set" predicate frames can help children make sense of the linguistic input they receive.

The predicate frames that the deaf children in our study have constructed parallel non-linguistic representations of the events these verbs encode, as Jackendoff (1990) might expect. But note that, although these frames may derive from non-linguistic representations, they truly are constructions on the part of the child. For example, there are many aspects of a transferring-object event that could have been – but are not – part of the deaf child's predicate frame (nor are they part of the predicate frame for transfer verbs in any natural language) – the original location that the object was in before it was moved, the locale in which the moving event took place, the time at which the event took place, and so on. The interesting point is that, even without benefit of linguistic input, children take three particular arguments (actor, patient, and recipient) to be essential to communicating about transferring-object events. Whether these three elements also have priority in other cognitive tasks that do not involve communication is not yet known, and bears on how task-specific predicate frames of this sort are.

2.2. Deletion as a Device for Marking Who Does What to Whom

The deaf children's gesture sentences are not only structured at underlying levels, but they are also structured at surface levels. The children use three different devices, all of which serve to indicate who does what to whom. I focus here on how children mark roles by producing them at particular rates in a sentence. As described in the preceding section, production probability is the likelihood that a particular thematic role or argument will be gestured in a sentence of a given length. Unlike the above analysis where we compared the production probability of a given role (e.g., the actor) across different underlying predicate frames, in this analysis we compare the production probability of different roles (e.g., the actor vs. the patient) in predicate frames of the same size. If the children haphazardly produce gestures for the thematic roles associated with a given predicate, they should produce gestures for patients equally as often as they produce gestures for actors in, for example, sentences about eating.

We find, however, that here again the children are *not* random in their production of gestures for thematic roles – in fact, likelihood of production distinguishes thematic roles. Both the American and Chinese deaf children are more likely to produce a gesture for the patient (e.g., the eaten cheese) in a sentence about eating than to produce a gesture for the actor (e.g., the eating mouse). Figure 2 presents production probability for actors and patients in two-gesture sentences with 2-argument transitive predicate frames (e.g., "eat"). Production probability is significantly lower for transitive actors than for patients for both groups of children (Goldin-Meadow & Mylander, 1998). Two points are worth noting.

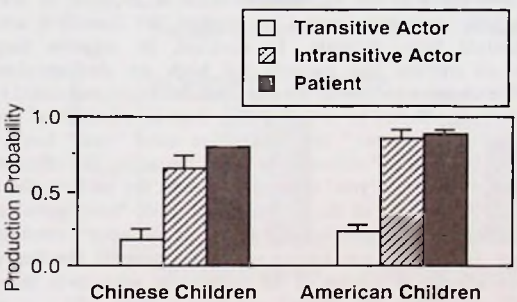

Figure 2. The Deaf Children Follow a Consistent Pattern When They Omit and Produce Gestures for Different Semantic Elements. The figure displays the likelihood that the American and Chinese deaf children will produce a gesture for a transitive actor, a patient, or an intransitive actor in a 2-gesture sentence. Both groups of children produced gestures for intransitive actors as often as for patients, and more often than they produced gestures for transitive actors. They thus displayed a structural arrangement reminiscent of the patterns found in ergative languages. Errors bars reflect standard errors.

First, the children's production probability patterns convey probabilistic information about who is the doer and the done-to in a two-gesture sentence. If, for example, a deaf child produces the gesture sentence "boy hit," we would infer that the boy is more likely to be the hittee (patient) in the scene than the hitter (actor) precisely because the deaf children tend to produce gestures for patients at the expense of transitive actors.

Second, note that the deaf children's particular production probability pattern tends to result in two-gesture sentences that preserve the unity of the predicate – that is, patient + act transitive sentences (akin to OV in conventional systems) are more frequent in the deaf children's gestures than actor + act transitive sentences (akin to SV in conventional systems).

Actors appear not only in transitive sentences with 2-argument predicate frames (*mouse*, eat, cheese) but also in *intransitive* sentences with 2-argument predicate frames (*mouse*, go, hole). How do the deaf children treat intransitive actors, the figure that moves itself to a new location? Figure 2 also presents production probability for actors in two-gesture sentences with 2-argument intransitive predicate frames (e.g., "go"). Both groups of children produce gestures for the intransitive actor (e.g., the *mouse* in a sentence describing a mouse going to a hole) as often as they produce gestures for the patient (e.g., the *cheese* in a sentence describing a mouse eating cheese), and far more often than they produce gestures for the transitive actor (e.g., the *mouse* in a sentence describing a mouse eating cheese).

This production probability pattern is reminiscent of case-marking patterns found in ergative languages (cf. Dixon, 1979; Silverstein, 1976). The hallmark of an ergative pattern is the way the intransitive actor is marked. In accusative languages like English, intransitive actors are marked like transitive actors and both are distinguished from patients. In contrast, in ergative languages, intransitive actors are marked like patients and both are distinguished from transitive actors. The ergative pattern in the deaf children's gestures could reflect a tendency to see objects as affected by actions rather than as effectors of action. In the sentence "you go to the corner," the intransitive actor "you," 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." *A priori* the decision to emphasize one aspect of the actor's condition over the other is arbitrary. By treating intransitive actors like patients, the deaf children are highlighting the affectee properties of the intranstive actor over the effector properties.

It is important to note that the deaf children really are marking thematic role, and not just producing gestures for the most salient or most informative element in the context. An alternative possibility is that the deaf children produce gestures for intransitive actors and patients more often than for transitive actors simply because intransitive actors and patients tend to be new to the discourse more often than transitive actors (DuBois, 1987). In other words, the production probability patterns seen in Figure 2 could be an outgrowth of a semantic element's status as "new" or "old" in the discourse. If the novelty of a semantic element is responsible for how often that element is gestured, we would expect production probability to be high for all new elements (regardless of role) and low for all old elements (again, regardless of role). However, we have found no evidence for this hypothesis. We reanalyzed the data in Figure 2, separating elements into those that were new to the discourse and those that were old. Figure 3 presents averaged data for the four Chinese deaf children and four age-matched American deaf children. The children produced gestures for transitive actors less often than they produced them for intransitive actors or patients, whether those elements were new (top graph) or old (bottom graph). Thus, we find an ergative production probablity pattern for new elements when analyzed on their own, as well as for old elements when analyzed on their own. This is as it should be if thematic role, rather than novelty, determines how often an element is gestured.

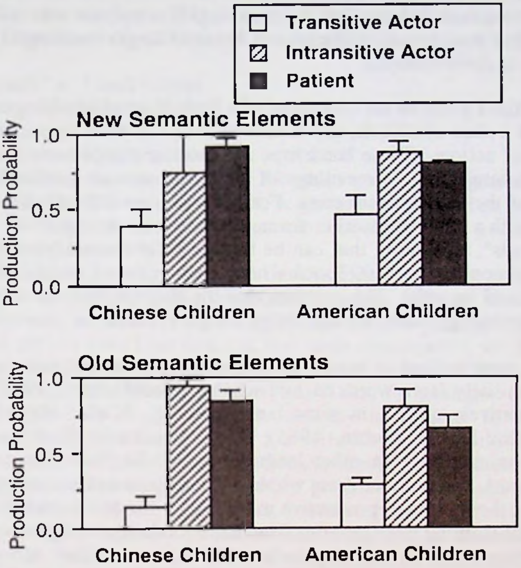

Figure 3. The Deaf Children Follow an Ergative Pattern Whether They Are Gesturing About New or Old Semantic Elements. The figure displays the likelihood that American and Chinese deaf children will produce gestures for transitive actors, intransitive actors, or patients when those elements are new (top) or old (bottom) to the discourse. The ergative pattern is evident in both graphs, suggesting that ergative structure at the sentence level is independent of the newness of the elements in discourse. Error bars reflect standard errors.

3. Word Level Structure

The deaf children produce gestures that are themselves composed of parts. The children could have faithfully reproduced the actions that they perform in the world in their gestures. They could have, for example, created gestures that capture the difference between holding a balloon string and holding an umbrella.

But they don't. Instead, they produce gestures that are characterized by three properties (Goldin-Meadow et al., 1995):

- Each child uses a limited set of discrete handshape and motion forms, that is, the forms are *categorical* rather than continuous;
- Each child consistently associates each handshape or motion form with a particular meaning (or set of meanings) throughout the corpus, that is, each form is *meaningful*;
- Each child produces most of the handshapes with more than one motion, and most of the motions with more than one handshape, that is, each handshape and motion is an independent and meaningful morpheme that could combine with other morphemes in the system to create larger meaningful units – the system is *combinatorial*.

Thus, the child's gestures are composed of a limited set of handshape forms, each standing for a class of objects, and a limited set of motion forms, each standing for a class of actions. These handshape and motion components combine freely to create gestures, and the meanings of these gestures are predictable from the meanings of their component parts. For example, an *OTouch* handshape form combined with a *Revolve* motion form means "rotate an object <2 inches wide around an axis", a meaning that can be transparently derived from the meanings of its two component parts (*OTouch* = handle an object <2 inches wide; *Revolve* = rotate around an axis). The gestures that the deaf children create thus form a simple morphology akin to the morphologies found in conventional sign languages.

At the very earliest stages of development, children acquiring conventional languages initially learn words as rote wholes (MacWhinney, 1978). They then realize – relatively quickly in some languages, e.g., K'iche' Maya (Pye, 1992), Turkish (Aksu-Koc & Slobin, 1985), West Greenlandic (Fortescue & Olsen, 1992) and more slowly in other languages, e.g., English (Bowerman, 1982), ASL (Newport, 1984) – that those wholes are composed of meaningful parts and begin to use those parts as productive morphemes. Since the deaf children in our study are not learning their gestures from adult models, we might expect them to show a different developmental pattern – that is, to use their sub-gesture hand and motion components productively even at the earliest stages of development. If so, we would then conclude that children begin by learning words as wholes rather than as combinations of parts *only* when they learn their words from a conventional language model.

On the other hand, it is possible that, even without a conventional language model, the child's first representation of an event is not in terms of parts, but rather in terms of the event as a whole. If so, the deaf child's first lexical items would not be composed of component parts but would instead be unanalyzed wholes which map (as wholes) onto an event. Later, perhaps when the child has accumulated a sufficient number of gestures in the lexicon, the child begins to consider his or her gestures in relation to one another and organizes the gestures around any regularities that happen to appear in the lexicon (i.e., the child treats his or her own gestures as a "problem space" that needs systematization, cf. Karmiloff-Smith, 1979).

For example, consider a child who early in development uses the following three gestures. Each gesture is used for a single object/action combination and for no other combinations and, in this sense, functions as an unanalyzed label:

- *O Touch + Revolve* = Key/Twist
- *O Touch + Short Arc* = Hat/Put-on
- *C Large + Revolve* = Jar/Twist

At some point, the child pulls back and considers the relations among these three gestures. The child notices that the *OTouch* handshape recurs across the gestures, as does the *Revolve* motion. These recurring forms are, for the first time, separated out from the whole and treated as component parts, each with its own meaning:

- *O Touch* = Small Object
- *C Large* = Large Object
- *Revolve* = Rotate
- *Short Arc* = Reorient

The transition is from a state in which the child considers a gesture only in relation to the situation conveyed – that is, a gesture-*world* relation – to a state in which the child begins to consider gestures in relation to other gestures in the system – a gesture-*gesture* relation.

If the deaf children were to follow this developmental path, we would expect that a particular handshape/motion combination, when still an undecomposed whole, might be used exclusively for a single object/action pairing. Later, when the parts of the gesture have been isolated, that same combination would be used for a variety of related objects and a variety of related actions. This is precisely the pattern we find (Goldin-Meadow et al, 1995). Take, for example, David who first uses a *Fist+Arc To & Fro* combination only in relation to drumstick-beating. In later sessions, David uses the *Fist+Arc To & Fro* combination not only for "drumstick-beat" but also for "toothbrush-brush" or "handlebars-jiggle." That is, the *Fist* handshape in this and in other gestures is now used in relation to a variety of related objects (drumsticks, toothbrushes, handlebars – all of which are narrow and long), and the *Arc to & Fro* motion in this and in other gestures is used in relation to a variety of related actions (beating, brushing, jiggling – all of which involve repositioning by moving back and forth).

What I am suggesting is that the deaf children induce their morphological systems from the earliest gestures they themselves create. Indeed, the first holistic gestures that the children used seemed to set the stage for the system each child eventually generated. For example, in session 1, David used the *OTouch+No Motion* combination to describe holding a bubble wand, a narrow *long* object. In addition, he also used the *OTouch+Circle* combination to describe twisting a small key, a narrow *short* object. If these examples are representative of the gestures David used at the time, he would infer that the *OTouch* handshape is used for objects that have relatively narrow diameters but that can be either long (like the wand) or short (like the key). Thus, on the basis of *his own* gestures, David would infer a form/meaning pairing in which the *OTouch* form is associated with the meaning "handle an object <2 inches in width and any length".

In contrast, the first time David produced the *Fist* handshape, he used it in session 2 combined with *No Motion* to describe holding a bubble wand; that is, the *Fist+No Motion* combination was used for the same event as the *OTouch+No Motion* combination. However, the *Fist* was *not* used to describe any other objects during the early sessions: it was used only for a narrow, long object and not for narrow, short objects. On the basis of these gestures, David would infer that the *Fist* handshape is used for objects that have narrow diameters and *long* lengths. In fact, when he began to consistently use gestures in relation to a variety of objects and actions in session 4, David used the *Fist* (combined with the *Arc To & Fro* and the *Short Arc* motions) to describe a set of objects, all having narrow diameters (<2") and long lengths (>3"), e.g., the handle of a hammer, the handlebars of a bike, a newspaper, and the brim of a hat – precisely the range of objects eventually seen for this form (Goldin-Meadow et al., 1995).

Children learning conventional languages go through an initial stage in which they learn words as wholes or amalgams, only later breaking those wholes into the component parts that characterize the language they are learning. This "start-with-the-whole" strategy could reflect the fact that these children are learning an established system handed down to them by their communities. However, the fact that the deaf children in our studies also go through an initial stage in which their gestures are unanalyzed amalgams suggests that this strategy is more basic. It is a strategy that *all* children bring to language-learning whether or not they are exposed to a conventional language.

After their initial holistic period, children begin to derive a morphological system using whatever input they have. If learning a conventional language, they survey the words they have learned and extract regularities across those words. If constructing their own gesture system, they survey the gestures they have created and extract whatever regularities exist in those gestures. Thus, the morphological systems that children construct reflect regularities in input, even in deaf children who must provide their own input. The important point to note, however, is that the drive to analyze and systematize one's lexicon is robust in young children, robust enough that it does not have to be catalyzed by a conventional language.

4. Do the Gestures that Hearing Speakers Produce While Talking Resemble the Deaf Children's Gestures?

Hearing parents gesture when they talk to young children (Bekken, 1989; Shatz, 1982; Iverson, Capirci, Longobardi & Caselli, 1999). The hearing parents of our deaf children are no exception. The deaf children's parents were committed to teaching their children to talk and talked to them as often as they could. And when they talked, they gestured. Although the deaf children in our studies had not been exposed to a conventional sign language, the spontaneous gestures that their hearing parents produced could have served as a model for the children's gesture systems. To explore this possibility, we analyzed the spontaneous gestures produced by the hearing mothers of six of our American deaf children (Goldin-Meadow & Mylander, 1983, 1984). We turned off the sound and coded the mothers' gestures as though they had been produced without speech. In other words, we attempted to look at the mothers' gestures through the eyes of a child who cannot hear. In general, we found that the mother's gestures did not resemble their children's – the children themselves seem to be responsible for the structure in their gesture systems.[1] I illustrate this point with an analysis of how often the mothers produced gestures for particular semantic elements. Figure 4 presents averaged data for the six mothers and their children.

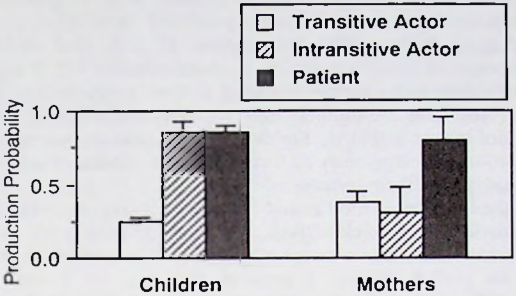

Figure 4. Hearing Mothers Do Not Use the Same Production Patterns in their Gesture Sentences as Their Deaf Children. The figure displays the likelihood that the hearing mothers of six deaf children will produce a gesture for a transitive actor, a patient, or an intransitive actor in the spontaneous gestures that they produce along with their talk. The mothers' gesture production probability patterns did not match their children's, suggesting that the mothers' gesture sentences could not have served as a straightforward model for their deaf children to copy. Error bars reflect standard errors.

The figure makes it clear that the mothers' gesture production patterns were different from their children's. However, the averaged data hides the fact that the mothers did not display a uniform pattern. Only one mother's gesture sentences conformed to the averaged mother pattern displayed in Figure 4. In contrast, the gesture sentences of five of the six children conformed to the averaged child pattern displayed in the figure (see Goldin-Meadow, 2003a, for individual data). Thus, not only did the mothers' gesture sentences differ from their children's, but there was no one pattern that characterized the gesture sentences produced by the hearing mothers.

---

1. The gestures that the deaf children produced evoked reactions from their hearing communication partners, and these responses might have shaped the deaf children's system. We considered this possibility but found no support for it (Goldin-Meadow & Mylander, 1984). We explored whether the patterns seen in the deaf children's gestures are particularly comprehensible to hearing adults, *any* hearing adults. It turns out that they are not. We also explored whether the hearing parents of *these particular* deaf children responded differently to gestures that conformed to their children's patterns than to gestures that did not conform to those patterns. Again, we find that they do not.

We also took the word-level analysis conducted on the gestures of four of the American children and conducted it on their mothers' gestures. We asked whether the handshape and motion morphemes that worked so well to describe the children's gestures would work equally well to describe the mothers' gestures. We found that they did not (Goldin-Meadow et al., 1995). Each mother used her gestures in a more restricted way than her child. She omitted many of the morphemes that the child produced (or used the ones she did produce more narrowly than her child). And she omitted a very large proportion of the handshape/motion combinations that her child produced. In addition, as described earlier, we had good evidence that the gestures of each deaf child can be characterized in terms of handshape and motion components which map onto a variety of related objects and a variety of related actions, respectively. However, there was *no* evidence that the mothers ever went beyond mapping gestures as wholes onto entire events – that is, the mothers' gestures do *not* appear to be organized in relation to one another to form the same system of contrasts that their children displayed in their gestures.

Strikingly, the fit between mother and child did not improve over time. We focused on an individual mother/child dyad and calculated how many of mother's gestures conformed to her child's morphological system at each of 7 sessions over a two year period. Figure 5 presents the data for David's mother. Approximately 50% of the handshape and motion forms that mother produced when David was 2 years, 10 months old fit David's system. In contrast, over 90% of David's handshape and motion forms fit this system (Goldin-Meadow & Mylander, 1990). Moreover, the proportion of mother's fits hovered around 50% for the entire two year period.

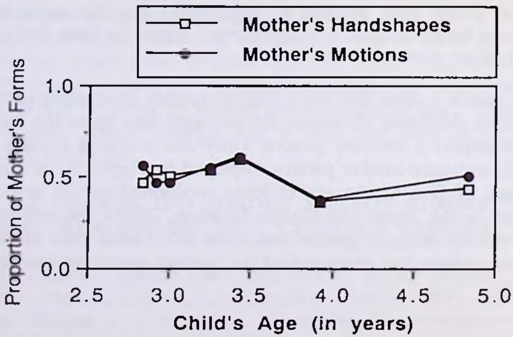

Figure 5. Mother's Gestures Do Not Become More Like Her Child's Over Time. The graph displays the proportion of mother's handshape and motion forms that conformed to her child's system of form-meaning pairings.

Given that mother and child were interacting with one another on a daily basis, we might have expected that over time their gestures would converge on a single pattern. But they didn't. David used his gestures in his way and his mother used her gestures in hers. The question is why.

The answer, I believe, has to do with the fact that the mothers always produced their gestures while talking. Like all hearing speakers' gestures (McNeill, 1992), the gestures that these mothers produced formed an integrated system with their speech. The mothers' gestures were therefore not "free" to take on the resilient properties of language found in their deaf children's gestures – their gestures were constrained by the spoken system of which they were a part. The gestures that hearing speakers produce while talking do convey information and do so using imagery. However, the forms that those gestures assume are very different from the forms found in the deaf children's gestures. The gestures that accompany speech are not segmented into discrete units. They do not have meanings that are stable across uses. They do not systematically combine with each other to form structured gesture strings. Their structure lies in their relation to speech (Goldin-Meadow, 2003b).

The claim is that the hearing mothers do not make their gestures conform to their deaf children's gestures because, as long as they are talking, they cannot. But what would happen if the mothers were forced to keep their mothers shut? The next section addresses this question.

5. When Does Gesture Become Language?

I am suggesting that gesture assumes the forms of language only when it is required to take full responsibility for the functions of language – when it functions without speech, not with it. To test this hypothesis, we have conducted a series of experiments in which we ask hearing adults to describe scenes with and without speech. We predicted that the gestures the adults would produce *without* speech would be segmented and combined into sentence-like strings and, as such, would be distinct from the gestures these same adults would produce spontaneously when they describe the scenes *with* speech (Goldin-Meadow, McNeill & Singleton, 1996).

This experiment attempts to simulate the deaf child's language-creating situation. However, we used hearing adults not deaf children as creators. There are two, very obvious differences between the adults and the deaf children. First, the adults already know a conventional language (English) and thus their created gestures could be heavily influenced by the particular language that they know. Second, the adults are not children and thus are well beyond whatever critical period there is for language-learning (and perhaps for language-creating as well). To the extent that we find differences between the gestures that the adults and the deaf children create, age and language-knowledge become likely candidates for causing those differences. But to the extent that the gestures created by the adults and deaf children resemble one another, we have evidence that the created structures do *not* reflect a child-like way of organizing the world – and that they may well reflect the effect of gesture assuming the primary burden of communication. Adults, even those who already have a language, may organize their manual-only communications in precisely the same ways as the deaf children, raising the possibility that the language-like properties found in the deaf children's systems result from trying to get information from one human mind to another in real time.

We asked English-speakers who had no knowledge of sign language to participate in the study. We showed the adults videotaped vignettes of objects and people moving in space from the test battery designed by Supalla, Newport and their colleagues (2003) to assess knowledge of ASL. Half the scenes contained only one moving object (e.g., a porcupine wandering across the screen) while the other half contained one moving object and one stationary object (e.g., a donut-shaped object arcing out of an ashtray). The adults were asked to describe each event depicted on the videotape twice, first using speech and then in a second pass through the scenes, using only their hands. We examined whatever gestures the adults produced in their first pass through the events (the Gesture+Speech condition) and compared them to the gestures they produced in their second pass (the Gesture condition).

As predicted, we found that the adults' gestures resembled the deaf children's in the Gesture condition but not the Gesture+Speech condition. Specifically, in the Gesture condition, the adults produced clearly articulated gestures which were often combined into connected strings. Moreover, the strings were reliably ordered, with gestures for certain semantic elements occurring in particular positions. Interestingly, all of the adults used the same gesture order and that order did *not* follow canonical English word-order. For example, in one scene, the adults saw a donut-shaped object rising on its own in an arc out of an ashtray and landing on a nearby table. To describe this scene in the Gesture alone condition, one adult produced a string of four gestures. Each gesture was crisp (with clearly formed handshapes and motions) and segmented, and the string of four was produced without any pause or break in the flow of motion.

(5) a. The adult brought his right hand shaped in a "V" to his lips as though smoking a cigarette (=ashtray);
  b. He cupped his left hand in a large "C" with the fingers spread forming a dish-like shape and bounced his right hand with his fingers bunched into a squashed "O" as though stubbing out a cigarette (= ashtray);
  c. He drew a circle in the air with his right hand in a well-formed point (= donut-shaped object);
  d. He formed his right hand into a round "O" shape and arced it out of his left, still in the shape of the dish (= arc-out).

The adult's gestures thus followed the order "ashtray donut arc-out" (Stationary object - Moving object - Action = SMA), rather than the typical English order "donut arc-out ashtray". The SMA order is typical of adults creating their own gestures on the spot (Goldin-Meadow et al, 1996; Gershkoff-Stowe & Goldin-Meadow, 2002). The adults not only displayed a non-English order pattern, but they also displayed a non-English production probability pattern. Their gesture sentences assumed an ergative production probability pattern (Goldin-Meadow, Yalabik & Gershkoff-Stowe, 2000), thus resembling the deaf children's gesture sentences rather than the gesture sentences that the children's hearing mothers produced as they talked (see Figure 4).

In contrast, in the Gesture+Speech condition, although the adults did produce gestures that conveyed information about actions and objects, they rarely combined those gestures into sentence-like strings. Moreover, their handshapes were loosely formed and sloppy. For example, the same adult who produced the "ashtray donut arc-out" SMA sequence in the Gesture condition, followed typical English word order when describing the scene in the Gesture+Speech condition. He said, "a crooked circular donut shape moved from out....from within a yellow ashtray." The gestures he produced were timed along with these words and followed roughly the same English order. Importantly, however, the gestures were *not* connected to one another – each gesture was followed by a pause and relaxation of the hands.

(6) a. The adult made a small arcing motion away from his body with his left hand in no particular shape (= arc).
[He paused and returned his hands to his lap].
b. He made a larger arcing motion that crossed space, this time with his hand in a loose "O" shape (= arc-out).
[He paused and returned his hands to his lap].
c. He indicated the spot where his arc had begun with a sloppy point and rotated his hand twice in the air (= ashtray)

The gestures that the adult produced while talking were loosely constructed and did not cohere into a unified string. In this sense, they were very different from the deaf children's gestures, and very different from the gestures this same adult produced when called upon to speak only with his hands.

In sum, when gesture accompanies speech in ordinary conversation, the imagistic information it conveys is an important part of the communication (Goldin-Meadow, 1999; 2003b). However, this function can be sacrificed (although not completely lost) when gesture is called upon to carry the full burden of communication. When gesture is the *only* modality available, it is no longer purely driven by imagery. Instead, it assumes the segmented and combinatorial form required for symbolic human communication – and it does so whether the gesturer is an adult or a child.

Are the structures found when gesture is called upon to fulfill the functions of language unique to communication? For example, does the SMA order found in the adults' gesture strings reflect the way that the adults think about events of this sort even when they are not communicating? Or does the SMA order merely reflect the way that the adults communicate about these events in the manual modality? In other words, does the SMA order arise *only* when a person attempts to share information with another, or does it crop up in non-communicative contexts as well?

To find out, we asked adults to reconstruct scenes using transparent pictures that could be stacked on top of one another. In one condition, the adults were asked to reconstruct the scene while describing what they were doing in English to the experimenter. In the other condition, the experimenter was blocked from view and the adults were instructed only to reconstruct the scene. Unbeknownst to them, what we were really interested in was whether they used a consistent order when creating the stack. We found that adults in both conditions did indeed reconstruct the scenes in an ordered fashion. Interestingly, however, the particular orders they used were quite different depending on the experimental condition. The adults who talked while reconstructing the scene, perhaps not surprisingly, often placed their pictures in the stack following English word-order – the picture for the donut came first, then the picture for the action (a cartoon-like directional sweep), and finally the picture for the ashtray. In contrast, the adults who reconstructed the scenes in the non-communicative context used the same SMA order that we found in our adult gesture-creation study – the picture for the ashtray came first, then the gesture for the donut, and finally the gesture for the action (Gershkoff-Stowe & Goldin-Meadow, 2002). Finding the same non-English order in a non-communicative context suggests that the order is *not* driven solely by communication in the manual modality, but may be a more general property of human thought.

Thus, in two studies – one in which adults were asked to create a "language" to describe a scene to another, and a second in which adults were asked to reconstruct a scene for themselves – we find that it is completely natural for humans to sequence symbols that represent semantic roles according to a consistent order. Whether or not adults are communicating, they place symbols for particular semantic roles in particular sequential positions. The reliance on ordering devices that is found in all natural languages is therefore likely to reflect general processing strategies that are not necessarily specific to language.

In addition to this general predisposition to sequence symbols for semantic roles according to a consistent order, we also find a *specific* order that appears to serve as a default for sequencing semantic roles, SMA. This order is used when adults reconstruct an event for themselves, and when they communicate the event to another in gesture without talking. However, this order is *not* the canonical order that most conventional languages offer their speakers to describe such events – many conventional languages, including English, override the default order (whether there is a cognitive cost to doing so is an open question). Thus, although ordering itself is a general cognitive skill that all languages exploit, the particular orders that languages adopt are quite specific to language. They do not necessarily reflect a general (i.e., non-language) way of viewing the world, but instead may be arbitrary outgrowths of the many pressures that conspire to make language what it is (see Slobin, 1977).

6. Resilient and Fragile Properties of Language

Gesture is remarkably versatile in form and function. It assumes an unsegmented and imagistic form when it works together with speech to communicate. But it assumes a segmented and combinatorial form when it takes over the functions of language from speech. The emergence of segmentation and combination (including ordering) in the experimental paradigms we have used with adults underscores the resilience of these grammatical properties in symbolic human communication. With little time for reflection, the adults in our studies constructed a set of gestures characterized by segmentation and combination. However, our simple experimental paradigm was not sufficient to support the emergence of all of the grammatical properties that we find in the deaf children's gesture systems. The adults' gestures were not organized into a system of internal contrasts, that is, into a morphology.

When the hearing adults generated a gesture, their goal was to produce a handshape that adequately represented the object, and their choice of handshapes appeared to be constrained *only* by their imaginations and the physical limitations imposed by their hands (that is, how the gesture relates to the world). For example, a hearing adult might produce a different handshape for each of the five airplanes on the test, with each handshape capturing an idiosyncratic property of the airplane pictured in that event. In contrast, when the deaf children in our studies generate a gesture, their choice of handshapes is guided not only by how well the handshape captures the features of the object, but also by how well that handshape fits into the set of handshapes allowed in their individual gesture systems (that is, how the gesture relates to other gestures in the set). Thus, they use the same handshape for all airplanes (indeed, for all vehicles), regardless of their individual idiosyncracies, and this handshape contrasts with the handshape used to represent, say, curved objects.

The fact that adults instantly invent a gesture system with segmentation and combination but without a system of internal contrasts suggests that some properties of language may be more resilient than others. Indeed, even though the deaf children in our studies do develop a gesture system with morphological structure, they do not incorporate into their gesture systems all of the properties found in natural human languages. In fact, the absence of a particular linguistic property in the deaf child's gesture system can be taken as indirect evidence of that property's relative lack of resilience. Such a property is likely to need exposure to a conventional linguistic system in order to be developed (for example, a system for marking tense). In general, these *fragile* properties of language need a more specified and particular set of environmental circumstances within which to develop than do resilient properties of language.

What do children require to develop the more fragile properties of language? A language model will clearly suffice. But are there other less optimal circumstances that would also permit the fragile properties of language to flourish? Perhaps having a community of speakers or signers or, at the least, a willing communication partner would allow the fragile properties of language to emerge even without a language model. Recall that the deaf children's families chose to educate them through an oral method, and their emphasis was on their children's verbal abilities. The families did not treat the children's gesture as though it were a language. In other words, they were not equal partners in the gestural communication that the children used.

I have often wondered how far a deaf child could move toward arbitrariness and a more complex system without a conventional language as a model but *with* a willing communication partner who could enter into and share an arbitrary system with the child. But the circumstance that would allow me to address this question – two deaf children inventing a gestural system with no input from a conventional sign language – has not presented itself. However, this question has been addressed on a much broader scale. Due to unusual political circumstances, a group of homesigners in Nicaragua were brought together to form a community in 1980. Over the course of two decades, a sign language appearing to have much of the grammatical complexity of well-established sign languages has evolved out of this set of home sign systems (Kegl, Senghas & Coppola, 1999). This newly emergent language is referred to as Lengua de Signos Nicaraguense, Nicaraguan Sign Language, and it appears far more complex than any of the homesign systems out of which it was formed – and far more complex than the gesture systems of the deaf children I have described here. The considerable distance between the deaf children's gesture systems and the newly-formed Nicaraguan Sign Language highlights the importance of a community of signers, and generations of signers, in constructing a full-blown linguistic system.

Nicaraguan Sign Language thus offers us a unique opportunity to watch a language become increasingly complex over generations of creators. The initial step in the creation process took place when the deaf children came together for the first time. Like the deaf children described here, these children had invented gesture systems in their individual homes. When brought together, the children developed a common sign language out of these home sign systems. Not surprisingly, then, we see the resilient properties of language in the sign language created by this first cohort of signers. For example, unlike the gestures that Spanish-speakers use when they talk, the signs that this first cohort uses are segmented, with each semantic primitive represented as an independent element (Senghas, Ozyurek, & Kita, 2003). Moreover, the signers combine their signs as do our American and Chinese deaf children, adhering to consistent word orders to convey who does what to whom (Senghas, Coppola, Newport & Supalla, 1997).

But Nicaraguan Sign Language has not stopped there. Every year, new students enter the school and learn to sign among their peers. This second cohort of signers has as its input the sign system developed by the first cohort and, interestingly, changes that input so that the product becomes more language-like (Senghas, 1995; Senghas et al., 1997; 2003; Senghas & Coppola, 2001). The second cohort, in a sense, stands on the shoulders of the first. These signers do not need to invent the resilient properties of language – those properties are already present in their input. They can therefore take the transformation process one step further.

However, it is the Nicaraguan home signers – and the deaf children described here – who appear to take the first, and perhaps the biggest, step. They transform their hearing parents' gestures, which are *not* structured in language-like ways, into a language-like system that contains the resilient properties of language (Coppola, Newport, Senghas & Supalla, 1997). The first and second cohort of Nicaraguan signers are then able to build on these properties, creating a system that looks more and more like the natural languages of the world.

Thus, across the globe, deaf children who are not exposed to a usable conventional language model will invent gestures to communicate. This, by itself, is not striking. What is striking is that the gesture systems the children create are structured just like natural languages. Indeed, all of the structures that we have identified in the deaf children's gestures systems can be found in natural language systems that have evolved over generations (and, in fact, are properties of language that linguists take for granted – the ones they never fight over). This is an important result as it indicates the naturalness of these kinds of structures to human communication. Strikingly, however, these structures do *not* appear in the gestures that routinely accompany speech. They are thus not inevitable in the manual modality, but are only inevitable when the manual modality assumes the functions of language on its own.

The deaf children incorporate many of the most basic properties of natural languages into their gesture systems. But they don't include all of the properties found in natural languages. Some properties of language undoubtedly require the presence of a conventional language model to develop. Others don't. The gesture systems that the deaf children generate offer an ideal paradigm within which to discover which properties are which. And, in the process, we not only gain a unique perspective on how children learn language, but we also discover just how resilient language is.

References

Aksu-Koc, A.A., & Slobin, D.I. (1985). The acquisition of Turkish. In D.I. Slobin (ed.), A cross-linguistic study of language acquisition, Volume 1 (pp. 839-878). Hillsdale, N.J.: Erlbaum.

Bekken, K. (1989). Is there "Motherese" in gesture? Unpublished doctoral dissertation, University of Chicago.

Bickerton, D. (1998). Catastrophic evolution: The case for a single step from protolanguage to full human language. In J.R. Hurford, M. Studdert-Kennedy, & C. Knight (eds.), Approaches to the Evolution of Language (pp. 341-358). Cambridge: Cambridge University Press.

Bowerman, M. (1982). Reorganizational processes in lexical and syntactic development. In E. Wanner and L. R. Gleitman (eds), Language acquisition: The state of the art. New York: Cambridge University Press.

Butcher, C., Mylander, C., & Goldin-Meadow, S. (1991). Displaced communication in a self-styled gesture system: Pointing at the non-present. Cognitive Development, 6, 315-342.

Chomsky, N. (1982). Lectures on government and binding: The Pisa lectures. Holland: Foris Publications.

Coppola, M., Senghas, A., Newport, E.L., & Supalla, T. (November, 1997). The emergence of grammar: Evidence from family-based sign systems in Nicaragua. Paper presented at the Boston University Conference on Language Development.

Dixon, R. M. W. (1979). Ergativity. Language, 55, 59-138.

DuBois, J.W. (1987). The discourse basis of ergativity. Language, 63, 805-855.

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

Fortescue, M., & Olsen, L. L. (1992). The acquisition of West Greenlandic. In D.I. Slobin (ed.), A cross-linguistic study of language acquisition, Volume 3 (pp.111-219). Hillsdale, N.J.: Erlbaum.

Gershkoff-Stowe, L., & Goldin-Meadow, S. (2002). Is there a natural order for expressing semantic relations. Cognitive Psychology, in press.

Goldin-Meadow, S. (1982). The resilience of recursion: A study of a communication system developed without a conventional language model. In E. Wanner & L. R.

Gleitman (eds), Language acquisition: The state of the art, (pp. 51-77). New York: Cambridge University Press.
Goldin-Meadow, S. (1985). Language development under atypical learning conditions: Replication and implications of a study of deaf children of hearing parents. In K. Nelson (ed.), Children's Language, Vol. 5 (pp. 197-245). Hillsdale, N.J.: Erblaum.
Goldin-Meadow, S. (1987). Underlying redundancy and its reduction in a language developed without a language model: The importance of conventional linguistic input. In B. Lust (ed.), Studies in the acquisition of anaphora: Applying the constraints, Vol. II, (pp. 105-133). Boston, MA: D. Reidel Publishing Co.
Goldin-Meadow, S. (1999). The role of gesture in communication and thinking. Trends in Cognitive Science, 3, 419-429.
Goldin-Meadow, S. (2003a). The resilience of language. N.Y.: Psychology Press, in press.
Goldin-Meadow, S. (2003b). Hearing gestures: How our hands help us think. Cambridge, MA: Harvard University Press, in press.
Goldin-Meadow, S., Butcher, C., Mylander, C. & Dodge, M. (1994). Nouns and verbs in a self-styled gesture system: What's in a name? Cognitive Psychology, 27, 259-319.
Goldin-Meadow, S., Gelman, S. A., & Mylander, C. (2003). Making generic statements with and without a language model. Under review.
Goldin-Meadow, S., McNeill, D., & Singleton, J. (1996). Silence is liberating: Removing the handcuffs on grammatical expression in the manual modality. Psychological Review, 103, 34-55.
Goldin-Meadow, S., & Mylander, C. (1983). Gestural communication in deaf children: The non-effects of parental input on language development. Science, 221, 372-4.
Goldin-Meadow, S., & Mylander, C. (1984). Gestural communication in deaf children: The effects and non-effects of parental input on early language development. Monographs of the Society for Research in Child Development, 49,1-121.
Goldin-Meadow, S. & Mylander, C. (1990). The role of a language model in the development of a morphological system. Journal of Child Language, 17, 527-63.
Goldin-Meadow, S. & Mylander, C. (1998). Spontaneous sign systems created by deaf children in two cultures. Nature, 91, 279-281.
Goldin-Meadow, S., Mylander, C., & Butcher, C. (1995). The resilience of combinatorial structure at the word level: Morphology in self-styled gesture systems. Cognition, 56, 195-262.
Goldin-Meadow, S., Yalabik, E., & Gershkoff-Stowe, L. (2000). The resilience of ergative structure in language created by children and by adults. Proceedings of Boston University Conference on Language Development, 24, 343-353.
Greenfield, P.M., & Savage-Rumbaugh, E. S. (1991). Imitation, grammatical development, and the invention of protogrammar by an ape. In N. A. Krasnegor, D. M. Rumbaugh, R. L. Schiefelbusch, & M. Studdert-Kennedy (eds.), Biological and behavioral determinants of language development (pp. 235-262). Hillsdale, N. J.: Earlbaum.
Iverson, J.M., Capirci, O., & Caselli, M. S. (1994). From communication to language in two modalities. Cognitive Development, 9, 23-43.
Jackendoff, R. (1990). Semantic Structures. Cambridge, MA: MIT Press.

Karmiloff-Smith, A. (1979). A functional approach to child language: A study of determiners and reference. N.Y.: Cambridge University Press.

Kegl, J., Senghas, A., & Coppola, M. (1999). Creation through contact: Sign language emergence and sign language change in Nicaragua. In M. DeGraff (ed.), Language creation and language change: Creolization, diachrony, and development (pp. 179-237). Cambridge, MA: MIT.

MacWhinney, B. (1978). The acquisition of morphophonology. Monographs of the Society for Research in Child Development, 43 (serial no. 174), 1-22.

McNeill, D. (1992). Hand and mind. Chicago, IL: University of Chicago Press.

Morford, J. P., & Goldin-Meadow, S. (1997). From here to there and now to then: The development of displaced reference in homesign and English. Child Development, 68, 420-435.

Newport, E. L. (1984). Constraints on learning: Studies in the acquisition of American Sign Language. Papers and Reports on Child Language Development, 23, 1-22.

Phillips, S.B., Goldin-Meadow, S., & Miller, P.J. (2001). Enacting stories, seeing worlds: Similarities and differences in the cross-cultural narrative development of linguistically isolated deaf children. Human Development, 44, 311-336.

Pye, C. (1992). The acquisition of K'iche' Maya. In D. I. Slobin (ed), The cross-linguistic study of language acquisition, Volume 3. Hillsdale, N.J.:Earlbaum.

Senghas, A. (1995). The development of Nicaraguan Sign Language via the language acquisition process. Proceedings of Boston University Child Language Development, 19, 543-552.

Senghas, A., & Coppola, M. (2001). Children creating language: How Nicaraguan Sign Language acquired a spatial grammar. Psychological Science, 12, 323-328.

Senghas, A., Coppola, M., Newport, E.L., & Supalla, T. (1997) Argument structure in Nicaraguan Sign Language: The Emergence of grammatical devices. Proceedings of Boston University Child Language Development, 21, 550-561.

Senghas, A., Ozyurek, A., & Kita, S. (2003). Encoding motion events in an emerging sign language: From Nicaraguan gestures to Nicaraguan signs. In A. Baker, B. van den Bogaerde and O. Crasborn (eds.), Crosslinguistic perspectives in sign language research. Selected papers from TISLR 2000. Hamburg: Signum Press, in press.

Shatz, M. (1982). On mechanisms of language acquisition: Can features of the communicative environment account for development? In E. Wanner & L. R. Gleitman (eds), Language acquisition: The state of the art, (pp. 102-127). New York: Cambridge University Press.

Silverstein, Michael. (1976). Hierarchy of features and ergativity. In R.M.W. Dixon (ed.), Grammatical categories in Australian languages (pp. 112-171). Canberra: Australian Institute of Aboriginal Studies.

Slobin, D. I. (1977). Language change in childhood and history. In J. Macnamara (ed.), Language learning and thought (pp. 185-214). N.Y.: Academic Press.

Supalla, T., Newport, E. L., Singleton, J. L., Supalla, S., Metlay, D., & Coulter, G. (2003). Test battery for American Sign Language morphology and syntax. Burtonsville, MD: Linstok Press, in press.

Tomasello, T. (2000). Do young children have adult syntactic competence? Cognition, 74, 209-253.