# The Generation of Standards of Form Within Communication Systems Over Different Timespans

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*If we consider the particular moment that an individual sits behind the wheel of an automobile for the first time, we can formulate this scenario in the context of three very different timespans: historical, microgenetic and ontogenetic. As this novice sits behind the wheel, around him a "history of the highway" continues along its own evolutionary trajectory where people, terrain and vehicles are co-constructing a system of transportation that reflects the integration of psychological, environmental and technological demands. While this novice may be merely a "blip" on a timeline, the fact that he has engaged in the act of driving at that moment underwrites him as a contributor to the collective behavior of driving.*

*Although this may be his first time behind the wheel, the novice driver is not totally ignorant. He brings to this scenario knowledge that he has acquired from years as an automobile passenger observing experienced drivers and paying attention to the interaction between cars and the road. "Rules of the road" (such as a 55 m.p.h. speed limit on certain stretches of highway or red octagonal signs with the letters S-T-O-P signaling drivers to cause their vehicle to stop moving) are not necessarily pieces of information that this novice learned from the Motor Vehicle Code. Rather, these are the kinds of standards that the novice acquired simply as a participant in a driving culture. While history contributes to the driver's experience, at the same time the driver himself is a part of the history in the making.*

*Yet history is not enough. When we consider this scenario from the driver's own perspective, using timespans that frame his "learning-to-drive" experience directly, we are likely to characterize the learning process quite differently. For example, we would all agree that this*

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*novice driver has much to learn beyond the generalities he has picked up as a passenger. He must develop the fundamental skill of driving (and simultaneously talking, eating, adjusting the radio or reading roadside symbols). He must learn to navigate his vehicle in both familiar and unfamiliar territories. Yet, again, this kind of "micro-tuning" ability does not come from reading the Motor Vehicle Code. Each novel experience will require the novice driver to respond "on the spot" and construct a new understanding of the elaborate set of objects and rules associated with the highway. It is the "microgenetic" timespan that frames this "on-line" process of responding to each new highway encounter.*

*Nevertheless, over time, the novice driver gains more experience and is better able to understand the symbols and meanings that underlie the "rules of the road." It is during this "ontogenetic" timespan—that is, the period of time within the driver's own lifespan that frames the mastery of a new skill—that the driver develops his own internal representation of "driving on the highway." More importantly, the set of rules now fits into a framework—no longer does the driver treat each "object" de novo. He now has "internal standards of form" and can use them to shape his own driving behavior and to interpret future driving encounters.*

*What this example illustrates is that the trajectory of the "learning-to-drive" curve is not simply unidimensional. As any novice builds a new framework of knowledge, more specifically internal standards of form, multiple timespans (historical, ontogenetic and microgenetic) must be considered as spheres of influence.*

*The research we describe in this article examines the processes that underlie the development of internal standards of form within communication systems. Specifically, we are interested in how time and function shape the construction of a coherent and internally consistent system of communication symbols. Thus, a snapshot of language creation at any particular point in time (much like the snapshot of the novice driver behind the wheel) contains linguistic forms that are simultaneously shaped by historical, microgenetic and ontogenetic processes.*

Natural languages are characterized by standards of well-formedness. These internal standards are likely to be, at least in part, a product of consensus achieved among language users over time measured in generations. In other words, a language is, to some extent, shaped by its history.

We ask here whether it is necessary for a language to evolve over historical time in order for it to be characterized by standards of well-formedness.[1] Might it not be possible, for example, for an individual,

1. See, e.g., Sapir, 1921, for a discussion of historical change in spoken language; see Frishberg, 1975, for a description of historical change in American Sign Language.

attempting to invent symbols to communicate *de novo* (either over a period of years or within minutes "on the spot"), to generate a system of symbols that is characterized by internal standards?

We have had the opportunity to compare communication that has been created over three distinct timespans — historical (over generations), ontogenetic (over the lifespan of an individual), and microgenetic (over a short period of perhaps minutes, hours, or days). We have used this opportunity to explore the forces that propel communication toward standards of well-formedness *viewed along the dimension of time.* We investigate whether an individual, attempting to invent symbols without the benefit of social consensus, might generate a system of symbols characterized by internal standards of form. We compare these self-generated systems to a conventional language that has been used by a community and passed down from generation to generation.[2]

We explore this issue by focusing on the manual modality, in particular, on gestured symbols. We concentrate on gesture for two reasons. First, the iconicity of the manual modality makes it possible for an individual to invent gestural symbols that can be understood immediately (e.g., pantomime); and second, data exist describing the gesture systems developed over years by children who have never been exposed to culturally shared sign systems.[3]

In this paper, we summarize research that examines the extent to which the following types of gestural communication become codified:[4] (1) American Sign Language (ASL), signs developed over a *historical* timespan; (2) "homesign," gestures developed over a period of years by a deaf child of hearing parents who have not yet exposed their child to ASL — that is, gestures developed over an *ontogenetic* timespan; and (3) invented gestures, gestures created "on the spot" by hearing individuals who have no knowledge of ASL or any other sign language and who have been asked by an experimenter to use their hands and not their mouths to describe a series of scenes — that is, gestures developed over a *microgenetic* timespan.[5]

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2. A detailed presentation of this research can be found in Singleton et al., 1993.

3. Goldin-Meadow et al., 1984; See also Kuschel, 1973 and Yau, 1985, each of whom describes a sign system invented by an isolated deaf individual; and Kendon, 1980a, Shuman, 1980, and Washabaugh et al., 1978, who describe sign languages that have arisen in isolated populations of deaf individuals.

4. We use the term 'codified' to refer to the outcome of a process by which linguistic forms become stable, having a consistent form-to-meaning relationship across various contexts of use.

5. It is important to note that gesture does not necessarily have to be structured in a language-like fashion. For example, Kendon (1980b; 1988) and McNeill (1992) have shown that gestures that accompany speech are viewed as an adjunct to speech, intricately linked with the timing and structure of the speech message—they cannot stand alone and are not characterized by internal standards of form.

## I. HISTORICAL TIMESPAN

We first describe the features of a manual communication system that has been passed down from generation to generation across a historical timespan, that is, a conventional sign language. It is not within the scope of this article to provide a detailed description of the linguistic structure of sign language.[6] We focus here only on the linguistic component that is relevant to our study — the morphological system — and we do so in one particular sign language — ASL.

ASL linguists have described a category of verbs called "verbs of motion and location."[7] These verbs typically encode action- or motion-based events (such as depicting a person diving into a swimming pool) through combinations of a limited set of discrete morphemes. These verbs are not analog representations of real world motions — rather, they are composed of a set of discrete forms (morphemes), each of which encodes a class of motions. For example, to describe a person who does a wiggly dive into a pool, an ASL signer would *not* represent the idiosyncrasies of the diver's trajectory into the pool, but would instead use a conventional morpheme representing 'change of location along an arced path,' combined with a second morpheme representing "random movement."

Despite their codified nature, verbs of motion in ASL are still rather iconic in form. Thus, we wondered whether a gesturer, one who does not know ASL, might nevertheless be able to spontaneously invent gestural symbols that resemble ASL morphemes — or, at the least, might be able to invent gestural symbols that are characterized by internal standards even if the particular forms are distinct from ASL. Before we explore this question, a few more details regarding the structure of ASL verbs of motion are necessary.

### *A. ASL Verbs of Motion: Linguistic Details*[8]

Every ASL verb of motion requires at least a CENTRAL OBJECT handshape morpheme (indicating the class of the object that is moving, that is, its category [e.g., a human, a vehicle] or its shape [e.g., round, straight]) and a ROOT motion morpheme (indicating the type of path traversed by the moving object, e.g., a linear path, an arced path, or a circle). For example, the ROOT morpheme "linear path" (representing change of location along a straight path) can be combined with one of

6. See Emmorey, 1994, for an overview of ASL linguistic structure.
7. McDonald, 1982; Newport, 1981; Schick, 1987; Supalla, 1982.
8. The linguistic description of ASL verbs of motion is based upon Supalla (1982; 1986).

many possible CENTRAL OBJECT morphemes representing the moving object (e.g., bent V = a small animal; thumb pointing up with the index and middle fingers extended = a vehicle). These combinations create a set of signs whose meanings are predictable from the meanings of the individual motion and handshape morphemes (i.e., a small animal moves along a straight path, a vehicle moves along a straight path). In another example, a different ROOT morpheme (e.g., "arc path," representing change of location along an arced path such as a jump forward) can be combined with these same CENTRAL OBJECT morphemes to create a set of signs whose meanings are also systematic combinations of the component parts of each sign (e.g., a small animal jumps forward, a vehicle jumps forward).

Along with the ROOT and CENTRAL OBJECT morphemes which are requisite in every verb of motion, the verb may also contain a variety of other morphemes. If the moving object has a special manner of motion along its path (e.g., bouncing or rolling), a MANNER morpheme is added to the verb. If the moving object has a special orientation or direction of motion (e.g., moving backwards or upwards), an ORIENTATION morpheme is added to the verb. Finally, if the moving object moves in relation to a second object, a classifier for the SECONDARY OBJECT (e.g., small animal or vehicle) is added, as well as a POSITION morpheme indicating the spatial relation of the secondary object relative to the path (e.g., the beginning or end of the path) and a LOCATION morpheme indicating the spatial relation of the central object relative to the secondary object at their point of contact (e.g., inside or on top of it).

To reiterate, ASL verbs of motion are complex form which typically encode action-based events. A single verb of motion can include up to two handshape morphemes (CENTRAL AND SECONDARY OBJECT) which characterize the objects, and up to five motion/location morphemes (ROOT, ORIENTATION, MANNER, LOCATION, POSITION) which represent movement and spatial aspects of the event.

## II. METHOD

In this research, we used a simple technique to elicit gestural communication from the participants in our study. Supalla (1982; in press) developed a video test designed to assess signers' knowledge of verbs of motion in ASL. This test is composed of 120 short filmed events of toy people and objects that move in varying paths and manners of motion, e.g., a doll jumping into a hoop, or a robot moving past a motorcycle. The animated film segments, each one to two seconds in length, can easily be depicted in gesture (in other words, a subject can generate a gestural symbol for the event even if that subject has no knowledge of ASL).

We presented Supalla's video test to one homesigner and to a group of nonsigners, and asked each participant to use gesture to describe each event. We were then able to analyze, and compare, the structural organization of the gestures that each individual created to encode a particular video event. Thus, our data set consists of two classes of gestures, each class generated to depict the same set of visually-presented targets: (1) gestures invented over the ontogenetic timespan by a deaf child who does not know ASL and uses a homesign gesture system to communicate with the hearing people around him, and (2) gestures invented "on the spot", that is, over the microgenetic timespan, by hearing nonsigners. In the next two sections, we characterize the set of gestures created over the ontogenetic timespan and then over the microgenetic timespan; in each section, we compare these two classes of invented gestures to a third set: (3) ASL verbs of motion invented by deaf people over generations, that is, gestures invented over the historical timespan.[9]

## III. ONTOGENETIC TIMESPAN

We ask first whether a deaf child whose hearing parents have not yet exposed him to ASL will nevertheless invent gestures composed of parts that resemble ASL morphemes. If not, we ask whether the child's gestures, although distinct from ASL, are nonetheless consistent within themselves.

Supalla's video test[10] was administered to a nine year-old deaf child of hearing parents who has been shown in previous work to have developed a gestural system which he used to communicate with the hearing individuals around him, that is, a "homesign" system.[11] We begin by describing the subject's linguistic background, and the materials and procedures used in administering the test to the child.

### *A. Subject and Procedures*

Deaf children born to deaf parents and exposed from birth to a conventional sign language such as ASL acquire that language naturally; that is, these children progress through stages in acquiring sign language similar to those of hearing children acquiring a spoken language.[12] However, ninety percent of deaf children are not born to deaf parents who

9. This "target ASL" data set is drawn from Singleton and Newport (1993). Based on data collected from a group of 8 native signing adults and 8 native signing children, Singleton and Newport established a data set that comprised typical ASL responses to each video target.
10. Supalla, 1982; Supalla et al., in press.
11. Goldin-Meadow et al., 1977; Feldman et al., 1978.
12. Newport et al., 1985.

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.[13] Unfortunately, it is extremely uncommon for deaf children with severe-to-profound hearing losses to acquire the spoken language of their hearing parents naturally, that is, without intensive and specialized instruction. Even with instruction, deaf children's acquisition of speech is markedly delayed when compared either to the acquisition of speech by hearing children of hearing parents, or to the acquisition of sign by deaf children of deaf parents. By age five or six, and despite intensive early training programs, the average profoundly deaf child has only a very reduced oral linguistic capacity.[14] Moreover, although many hearing parents of deaf children send their children to schools in which one of the manually coded systems of English is taught, some hearing parents choose to send their deaf children to "oral" schools which emphasize speech and in which sign systems are neither taught nor encouraged; thus, these deaf children are not likely to receive input in a conventional sign system.

The subject of this study, whom we call David, is profoundly deaf (>90dB bilateral hearing loss) and his hearing parents chose to educate him using an oral method. David participated in a longitudinal study conducted by Goldin-Meadow and her colleagues exploring the gestures developed by deaf children whose hearing losses prevent them from naturally acquiring the spoken language that surrounds them, and whose hearing parents have not yet exposed them to any form of a conventional sign system. As a participant in this longitudinal study, David was videotaped periodically in play sessions at his home beginning at age 2;10 (two years ten months). Despite his lack of a usable conventional language model, David was shown to have developed a gesture system that had many of the properties of language, particularly when compared to the linguistic systems developed by comparably aged children exposed to conventional language models.[15] In particular, there were compelling structural similarities between David's gestural system and conventional languages at lexical,[16] syntactic,[17] and morphological[18] levels, and functional similarities in the way the gestures and conventional systems were used.[19]

Supalla's video test was administered to David in his home when he was approximately nine years old by Elissa Newport and Ted Supalla in conjunction with one of us (SGM). At the time of this session, David had made little progress in oral language, occasionally producing single words

13. Hoffmeister et al., 1980.
14. Conrad, 1979; Geers et al., 1978; Meadow, 1968; Quigley et al., 1984.
15. Goldin-Meadow et al., 1990a.
16. Feldman et al., 1978; Goldin-Meadow et al., 1994.
17. Goldin-Meadow, 1982, 1987; Goldin-Meadow et al., 1977; Goldin-Meadow et al., 1984.
18. Goldin-Meadow et al., 1990b; Goldin-Meadow, et al., 1993.
19. Butcher et al., 1991.

but rarely combining those words into sentences. In addition, at this time, David had very limited exposure to ASL or to a manual code of English. One of the primary reasons we were convinced that David had only limited exposure to a conventional sign system was that he knew very few of even the most common lexical items of ASL or Manually Coded English, despite the fact that he was a superb gesturer. Moreover, when a native signer reviewed the tape taken of this session, she found that, while David did produce some ASL signs (TREE, GIRL, DOG), he failed to produce many ASL signs that are commonly known to young signers and produced his own gestures instead (e.g., rather than produce the sign KING, David traced the outline of a crown on his head to refer to a king).

The animated film segments were shown one at a time to David. After each filmed event, David was asked by Supalla, primarily through gesture, to depict what happened. The entire session was videotaped and David's videotaped responses were later coded by a native signer trained by Supalla for the seven types of ASL morphemes described above. Each response was scored for accuracy according to targets previously established for native ASL usage. David was assigned a score on each of the seven morpheme categories (the number of morpheme tokens which he produced correctly within a morpheme category such as ROOT, CENTRAL OBJECT, etc.). In addition, David's responses were analyzed a second time to determine whether his gestures, where they differed from ASL, nonetheless formed an internally consistent system within themselves.

### *B. Results*

We focus here on the handshapes that David used in his gestures (that is, on the forms most comparable to the CENTRAL and SECONDARY OBJECT morphemes of ASL).[20] We found that, when asked to describe scenes that are typically conveyed by verbs of motion in ASL, David constructed handshapes that captured quite well many characteristics of the objects displayed in the videotaped segments. However, these handshapes were not identical to the handshapes used in ASL. David failed to use some of the most common handshapes that ASL signers use on the Supalla video test,[21] and he used some handshapes that signers never use on the test.[22] Moreover, even when David did use the same handshapes as are used in

20. See Singleton et al., 1993, for a description of the motion and locations forms generated by the subjects in our studies.

21. E.g., David did not produce the ASL 'VEHICLE' classifier handshape (thumb pointing up, index and middle fingers extended).

22. E.g., David sometimes used a 'FIST' handshape, which is not an acceptable ASL response for any item on the test.

ASL, he frequently used them to capture different aspects of the object than are captured in ASL handshapes.[23]

Nevertheless, what is impressive about David's handshapes is not the differences between them and ASL, but the fact that they formed a *coherent and internally consistent system*, as does ASL. Indeed, David was found to be as consistent within his own system as native signers were within the ASL system. In other words, any gesture that David used was required, not only to convey the information displayed on the videotaped segment, but also to fit into a contrastive system of form-meaning categories — his choice of handshape provides information not only about the handshape used, but also about the set of handshapes *not* used. In this sense, David's gesture system can be said to possess standards of well-formedness of the sort that characterize conventional languages developed by communities of signers over long periods of time.

David developed his internally coherent morphological system without the benefit of systematic exposure to ASL, having only the spontaneous gestures that his hearing parents and hearing siblings used as input to his system.[24] The data therefore suggest that, even without the benefit of a conventional language model, a child can generate gestures which are characterized by a morphological system.

However, David's morphological system was quite simple — having only five simple handshapes[25] and a small number of rules characterizing the form of two-gesture strings.[26] Thus, David developed a gesture system distinguished by structure and consistency, but one with little complexity. It may be that *complexity* can be introduced into a linguistic system only if the system is used by a community of signers who transmit the system from one generation to the next. In contrast, *internal structure* in and of itself apparently can be introduced into a linguistic system by a single individual.

## IV. MICROGENETIC TIMESPAN

Next, we explore whether internal standards arise whenever an individual is asked to convey information of the sort displayed in the video test. To do so, we asked hearing individuals who had no knowledge of sign language to describe the segments in the video using only their hands, that is, using gesture and no speech. Our goal was to determine whether the gestural communication that an individual creates "on the

23. E.g., David used a 'PALM' handshape to characterize straight-wide objects *and* animate objects and vehicles; ASL signers would only use the 'PALM' handshape to represent straight-wide objects.

24. See Goldin-Meadow et al., 1983, 1984, 1990b, for a description of the spontaneous gestures David's mother produced.

25. Goldin-Meadow et al., 1990b.

26. Goldin-Meadow et al., 1984.

spot" is characterized by internal standards. To enhance comparisons with David, who was only nine years old when tested, we tested a group of hearing children as well as hearing adults.

### *A. Subjects and Procedures*

Sixteen hearing adults and five hearing children participated in this component of the study. None of these participants had knowledge of ASL or any other sign language. The adults were all students at the University of Chicago, and were recruited through sign-up sheets distributed in psychology classes or posted in various campus buildings. The children ranged from eight to ten years of age and were recruited through an after-school program at a local school and had parental permission to participate in the study.

The test was administered by the same experimenter for all subjects (JS) in a quiet room at the University of Chicago.[27] Each subject was first asked to view the segments and describe them; no mention was made of gesture for this first pass through the segments.[28] The subject was then asked to view the segments again, this time using gesture and no speech to depict what happened in each segment.

The subjects' gestures produced without speech were score initially according to the targets established for ASL, and then subsequently according to the targets established for David's gestures based on David's "internal standards of form."[29]

### *B. Results*

We asked hearing individuals to abandon their native tongues and to use gesture to depict objects moving in space in a series of videotaped segments. We found that, in general, the novice gesturers did attempt to

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27. To make data collection more manageable, we used only a subset of the 120 segments which comprise Supalla's (1982) Verbs of Motion Production test. We presented each subject with 38 segments. The segments were carefully selected so that there would be a sufficient number of exemplars in each of the seven morpheme categories within the revised set.

28. Data on the spontaneous gestures the subjects produced during this part of the study bear on the question of how gesture that accompanies speech differs from gesture that must carry the full burden of communication; results on this issue are described in Singleton, Goldin-Meadow and McNeil (1991; 1995) and Goldin-Meadow, McNeill and Singleton, (1995).

29. Reliability for transcribing the form of the gestures was established by first training six non-signers to code the gestures according to the system established by Supalla. Inter-coder reliability was then calculated between pairs of coders on a subset of the data, and was found to average 86% agreement. Reliability for classifying gestures according to ASL and David targets was established by having two trained observers (both of whom were fluent in ASL) independently code and classify the gestures of a subset of the subjects. There was 96% agreement between coders when classifying the gestures according to ASL targets, and 95% agreement between coders when classifying the gestures according to David targets.

encode in their gestures information about the objects displayed in the segments, and they did so with a certain amount of success. The handshapes they created captured many of the characteristics of the objects displayed in the segments. However, their handshapes did *not* resemble the handshapes of ASL nor, more surprisingly, did they resemble the handshapes of the homesigner.

Although the novices' handshapes were adequate in terms of representing each individual object in the segments, they failed to represent the set of objects *in a coherent and systematic fashion.*[30] The novice gesturers appeared to treat each handshape that they generated as an isolated symbol rather than as a member of a coherent set of symbols; that is, their handshapes each had a relationship to its referent but had no relationship to their other handshapes.

Thus, the novice gesturer appeared to strive for an effective representation of each individual filmed segment. Indeed, the handshapes that the novice gesturers created are most impressive when evaluated in terms of whether they were adequate to evoke the object displayed in the segment. In this sense, they are like pantomime, which is evaluated not in terms of well-formedness but rather in terms of its effectiveness in evoking the intended referent.[31] As a consequence, the handshapes the novice gesturers produced were adequate representations of each individual object, but those handshapes did *not* cohere into a system for representing *categories* of objects (as did the handshapes that the homesigner produced).

Our findings suggest that representing information in the gestural channel is not the primary problem for the novice gesturer; they seem to be able to do so with very little difficulty. Rather, it is the organization of information into contrastive and productive categories that appears to be difficult to achieve 'on the spot' and that may require the benefit of gradual development over a longer timespan.

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30. E.g., one of the child novice gesturers produced a different handshape each of the five times she represented an airplane on the test—her handshapes captured idiosyncratic properties of each airplane such as its wing and fuselage configuration. To represent the set of objects in a systematic fashion, the gesturer might have created a single, consistent gestural representation as a symbol for all airplanes (as did the homesigner, David).

31. For example, in pantomime, it matters not at all how the hands are shaped in holding an imaginary egg, nor how many fingers are straight or curved; what counts in pantomime is that the hands are held *as if* surrounding or holding an egg-shaped object. Bellugi et al., 1976: 520.

## V. DISCUSSION

### *A. Once Is Not Enough: Ontogenetic vs. Microgenetic Timespans in the Generation of Standards of Form*

McNeill (1992) argues that the comparison of codified signs (that is, conventional sign languages) and noncodified spontaneous gestures (that is, the gestures that speakers spontaneously produce along with their speech) within the same manual modality presents a unique view of the factors shaping language: Holding constant the modality, we see which properties are invariant and which properties are added by the conventionally structured code. In his extensive studies of the gestures that hearing speakers spontaneously produce along with their speech, McNeill has found that noncodified gestures differ from a sign system such as ASL in their lack of segmentation, compositionality, and standards of well-formedness. Thus, standards of form are *not* characteristic of the spontaneous gestures speakers produce along with their speech, but do arise when communication in the gestural mode becomes codified into a conventional sign language.

In our studies, we have attempted to hold modality constant in order to explore whether a historically developed conventional code is the only communication situation which allows standards of form to evolve in the manual modality. In addition, we hold constant the fact that the manual modality carries the full burden of communication — unlike spontaneous gestures which accompany speech and serve an adjunct role relative to the spoken system.

We found that, when an individual is asked to abandon speech and generate gestures "on the spot" to convey information, that individual — whether child or adult — is likely to be able to do so. Indeed, the gestures which are produced tend to be relatively good representations of the objects to be described. However, the gestures do not form a coherent system. The overriding consideration for the novice gesturer appears to be to maximize the way the gesture relates to the world, rather than to maximize the way the gesture relates to other gestures.

In contrast, we examined the gestures produced by a deaf child who, over a period of years, invented and used a spontaneous gesture system to communicate with his hearing parents and siblings. We found that the child's gestures not only were adequate representations of objects in the world, but they also conformed to an internally consistent and contrastive system; that is, they appeared to have standards of form. In addition, in an analysis of the spontaneous gestures that this child used over a two year period, Goldin-Meadow, Butcher, Mylander and Dodge (1993) found

that the child tended to use precisely the same gestural form for the same meaning throughout this relatively long period; that is, he appeared to have a stable lexicon of gestures at his disposal. The consistency that characterizes David's gestural communication system suggests that he is able to treat his gesture system as a "whole" in a kind of mental "problem-space"[32] and can evaluate (probably implicitly) the integrity of a particular form he constructs with respect to the "architecture" of his self-generated linguistic system.[33]

### *B. Time May Not Be Enough: Internal Consistency vs. Complexity*

Our data suggest that an individual, if given enough time, can introduce standards of form into a communication system within a single generation. Nevertheless, the gesture system of the deaf child in our study, although characterized by internal consistency, was far less complex a system than the sign languages passed down from generation to generation.[34] What prevented the deaf child David from developing a gesture system as complex as ASL? The fact that David was only a child may have limited the complexity of his gesture system. However, children of David's age can certainly learn languages with a great deal more complexity than David introduced into his gesture system.

David's family had chosen to educate him through an oral method and their emphasis was on David's (minimal) verbal abilities. They did not treat David's gesture as though it were a language. In other words, they were not partners in the gestural communication that David used. Thus, in order to be understood, David's gestures needed to be iconic, that is, transparently related to their referents.[35] An interesting question to pose is how far David could have gone in developing a complex communication system with a willing communication partner who could have entered into and shared an arbitrary system with him. To date, we have

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32. See Karmiloff-Smith, 1979 for a discussion of language as a "problem-space" for children acquiring linguistic forms and meanings.

33. One example of the awareness David has regarding his own standards of form comes from a moment captured on videotape in which David criticizes his hearing sister for producing a particular gesture. David reacts to her "mispronunciation" and goes on to ridicule her. He later shows her the "correct" handshape (according to his gesture system) for that context. Thus, David appeared to have a well-articulated sense of what counts as an acceptable gesture and was not shy about imposing his standards on the gestures of another person, namely, his sister.

34. Goldin-Meadow et al., 1984; 1990b.

35. Note that David's gesture was not absolutely limited by iconicity. There are instances in which the form David used was less mimetic than one might have expected. For example, David frequently depicted climbing a ladder, not as hands alternately grasping invisible rungs of a ladder while moving upward (as might be expected if the gesture were actually miming the act of climbing), but as hands alternately grasping *in place*, combined with a pointing hand moving upward. Despite instances of this sort, note that in order to ensure that his communication partners could understand him, David could not afford to stray too far from the iconic roots of his gestures.

not found a situation that might allow us to address this question — for example, two deaf children inventing a gestural system with no input from a conventional sign language.

Because of the unusual circumstances in which he finds himself, David must at least begin by inventing gestures that are iconic. Moreover, his circumstances do not allow him to stray too far from iconicity if his gesture system is to be understood. Note, however, that children who do not have to invent their language but have only to learn it appear to sidestep iconicity altogether.[36] These findings indicate that children will approach language as a formal system even if there is an apparently (from an adult's perspective) easier, iconic route open to them. Children appear to exploit iconicity only when it is necessary to do so, as in David's circumstances.[37]

## VI. CONCLUSION

In summary, our empirical research on the generation of well-formedness in gestural communication systems offers some insight into the *temporal* and *functional* factors that may contribute to the shaping of an internally coherent communication system. Gestures invented by our hearing nonsigners in the microgenetic timespan did provide a fairly good representation of the information the individuals were attempting to convey. However, taken together, these gestures did not form a coherent system — that is, there was an identifiable gesture-to-meaning relationship, but virtually no gesture-to-gesture relationship, within the set of gestures each individual nonsigner generated. In contrast, the deaf child inventing gestures in the ontogenetic timespan created gestures that not only were adequate representations of objects in the world but also conformed to an internally coherent and contrastive system — that is, they appeared to have standards of form, in much the same way as a full-fledged gestural language such as ASL.

While time appears to facilitate the development of a system whose symbols conform to *internally coherent standards of well-formedness*, time alone may not be sufficient. Our data also suggest that the symbols must be treated by their owner as having the explicit function of communication; that is, the forms must carry the full burden of communication in order for internal coherence to evolve. When forms serve as an adjunct

36. In a longitudinal study of spontaneous signing (1981) and in a cross-sectional study in an experimental setting (1987), Meier has shown that the iconicity available in sign language is *not* exploited by the language-learning child (see also Orlansky et al., 1984 and Folven et al., 1991).

37. Meier, 1987.

to communication (such as gestures that accompany the speech of hearing individuals), it appears that they are not driven toward systematization.[38]

In addition, it appears that *internal complexity* within the symbol system depends to some extent upon whether the system functions as communication for a single speaker or for a community. Until linguistic symbols are acknowledged, learned, and shared by others, the forms may be constrained by transparency and simplicity, and the opportunity for transmission from generation-to-generation (and concomitant historical change) may well be obstructed.

38. Singleton et al., 1995.

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