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Intergenerational influence and ontogenetic development in the emergence of spatial grammar in Nicaraguan Sign Language

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Abstract

The recent emergence of a new sign language among deaf children and adolescents in Nicaragua provides an opportunity to study how grammatical features of a language arise and spread, and how new language environments are constructed. The grammatical regularities that underlie language use reside largely outside the domain of explicit awareness. Nevertheless, knowledge of these regularities must be transmitted from one generation to the next to survive as part of the language. During this transmission, language form and use is shaped by both the characteristics of ontogenetic development within individual users and by historical changes in patterns of interaction between users. To capture this process, the present study follows the emergence of spatial modulations in Nicaraguan Sign Language (NSL). A comprehension task examining interpretations of spatially modulated verbs reveals that new form-function mappings arise among children who functionally differentiate previously equivalent forms. The new mappings are then acquired by their age peers (who are also children), and by subsequent generations of children who learn the language, but not by adult contemporaries. As a result, language emergence is characterized by a convergence on form within each age cohort, and a mismatch in form from one age cohort to the cohort that follows. In this way, each age cohort, in sequence, transforms the language environment for the next, enabling each new cohort of learners to develop further than its predecessors.

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To acquire a language, one must learn its vocabulary, the way it indicates the past, whether to include masculine or feminine endings on adjectives, and countless other intricate details specific to that language. These details seem to be learned easily with early exposure to a language (Newport, 1990), and reside largely outside the domain of explicit awareness. How do these language-specific features initially enter the language environment, and how does information that people know only implicitly perpetuate itself?

Individuals learn the specific features of a language through social contact with other speakers, not through explicit instruction. Language pedagogy in school, and written dictionaries and grammars, are not necessary for languages to be learned; indeed, language learning typically precedes literacy in even the most thoroughly documented languages. Such documents will not guarantee the perpetuation of a language either, as numerous documented but dead languages reveal. For a language to survive, it must be implicitly learned, and in the process, passed on. Through this process, every language that exists today has been molded by the nature of human learning and social interaction.

Languages are typically learned in childhood, and maintained in adulthood as a model for subsequent generations. As a result, existing languages naturally suit both the learning abilities of children and the patterns of adult–child social interaction. Each linguistic element of a language is subject to shaping by the nature of ontogenetic development of individual language users, and by the patterns of contact among them.

We can tap into the nature of learners and their interactions by examining the imprint of this shaping process. How closely do learners replicate the language of the generation before them? Which types of feature are learned easily, and which are not passed on? These questions are difficult to pursue with typical cases of language acquisition, as the language that is modeled for a learner has already been shaped over many generations, and learners converge closely with their model at each intergenerational transition. Mature languages are pre-sifted, in that features that are difficult for children to learn do not persist for long, and unlearnable features never become part of the next generation's language-learning environment. When a mature language is learned, the shaping effect of one generation's learning process is therefore imperceptibly small. Cumulative changes over many generations, however, reveal that the match from each generation to the next is not exact. The difference between the language of today's 14-year olds and *Romeo and Juliet* represents the change over 20 such generational transitions.

We might observe a more dramatic imprint of the nature of learners and their interactions when the information being learned has taken fewer runs through the acquisition mill. What do learners do when their language environment is incomplete or unusual? Do they replicate unusual features produced by others, and pass them on? Or do they change the language as they learn it?

The recent emergence of a new sign language¹ in Nicaragua provides us with the opportunity to explore a case where the language initially available in the environment was exceedingly incomplete. Changes in children's and adults' patterns of social contact, together with changing learning abilities, have created a complex interaction that is yielding a new language. The present study follows a single grammatical feature as it has appeared and spread through this young language community. This grammatical feature serves as a tool for us to explore the shaping influence of language transmission along both historical and ontogenetic timelines. In the sections that follow, we consider the history of the new language, and then examine the emergence of the particular aspect of its grammar.

1. Periods in Nicaraguan Sign Language history

1.1. Pre-Contact Period

Before the 1970s, deaf Nicaraguan children and adults had little contact with each other (Polich, 1998; Senghas, 1997, 2003). Societal attitudes that kept deaf individuals apart and marital patterns that generally precluded hereditary deafness both prevented intergenerational contact. Peer contact was also limited, as the few available primary schools served small numbers of children who did not have contact outside school and lost touch once they no longer attended.

Most of the deaf people in Nicaragua were the only deaf individuals in their families and neighborhoods. In such situations, deaf people will often develop *homesign* systems, that is, idiosyncratic and rudimentary gestural systems used to communicate with hearing family members (Goldin-Meadow, 1982; Morford, 1996). Homesign systems have been found to exhibit some of the central properties of languages, such as a basic vocabulary of gestures, and consistent underlying word order frames that allow recursion (Goldin-Meadow, 1982). The homesign systems developed by Nicaraguans most likely varied widely from one deaf person to another in form and complexity (Coppola, 2002).

Evidently, the conditions of the Pre-Contact Period were not adequate to support a community or a language. During this period no Deaf² community emerged, and no sign language could develop or be maintained.

¹ "Sign language" is not a single, universal system, any more than spoken language is. There are many different sign languages that have arisen among populations of deaf people who are in contact, and they vary from one geographical region to another, as spoken languages do. Sign languages are not alternate encodings of spoken languages (unlike systems like Braille and Morse code), and will differ even between those regions that share a spoken language. For example, although British Sign Language, American Sign Language, and Australian Sign Language (Auslan) are all used in regions where English is spoken, they are mutually incomprehensible, separate languages, each with its own grammar and lexicon.

² Consistent with other literature on deafness, *Deaf* written with an upper case *D* signifies cultural Deafness, that is, membership within a self-identified Deaf community; *deaf* written with a lower case *d* refers to the inability to hear (cf. Senghas & Monaghan, 2002, for a discussion of these distinctions).

1.2. Extensive Contact Period

Peer contact among deaf children increased dramatically toward the end of the 1970s. Most significantly, a center for special education opened in 1977, offering classes in deaf education from preschool through grade 6. Initially, approximately 50 deaf students enrolled, increasing to over 100 by 1979 (Polich, 1998). Although language instruction focused on lip-reading and speaking Spanish (with minimal success), the children were allowed to communicate gesturally on the buses and school grounds, and began to develop a new sign language together. Soon afterwards, in 1980, a vocational school for adolescents was established. By 1983, the schools served more than 400 deaf students (Polich, 1998). For the first time a Deaf community existed with continuity from childhood through early adulthood.

In 1986, a social club formed for deaf adolescents and adults. By 1990, this club became the National Association of Deaf Nicaraguans and was directed by Deaf adults. The Association actively promoted the use of the sign language and created opportunities for regular contact between deaf adults, adolescents, and children. These included social gatherings, Deaf-coached athletic teams, and, with the cooperation of the Ministry of Education, Culture, and Sports, the addition of Deaf teaching assistants to the primary school classrooms.

From its beginning in the mid-1970s to the present day, this Extensive Contact Period has been characterized by extensive *horizontal* contact, that is, interaction among peers of each age cohort, particularly among young children. As they approached the mid-1980s, the first cohort of children to be in contact began entering adolescence and adulthood. As they matured, they created situations that promoted intergenerational contact, that is, contact with a second, younger cohort of children just entering the community. Consequently, in addition to the constant *horizontal* influence among peers of each age cohort, this period was characterized by the gradual introduction of *vertical* influence from one age cohort to the next.

All of the participants in the present study were exposed to NSL in early childhood at some point during this Extensive Contact Period; hence, they are all fluent, native users of the language, and none were late-learners. However, they differ in the year in which they were first exposed, ranging from the mid-1970s to 1990. Our oldest participant was one of the young children who entered the special education elementary school when it first opened in 1977. She transferred with a few classmates from a smaller school, and recalls her initial contact into that peer group in 1974. Together they entered the new elementary school, and together they later attended the vocational school as adolescents. Thus, she and her peers were members of the *first cohort* to have continued peer contact from early childhood through the present day. Our youngest participant entered the special education school in 1990. Thus, he and his peers were members of the *second cohort*, which had extensive contact not only with peers, but also with adolescents and adults who had been developing the language over the previous 16 years.

Thus, the range of participants in the study represent the transition in social contact over the course of the 1980s, from solely horizontal, to a combination

of horizontal and vertical influence. We are interested in how this sociocultural development along a historical timeline interacted with individual ontogenetic development in building the grammar of this new language.

2. The selection of a linguistic feature for the study

The present study seeks to capture the innovation of a grammatical “rule” in NSL and examine its pattern of perpetuation through the language community. The grammatical elements evident in an individual’s version of the language reveal the nature of that individual’s language exposure. We sought to document the emergence and spread of a form by determining the year in which each individual who implicitly knows it first entered the signing community as a child.

For this analysis, we sought a grammatical element that combines words into longer utterances, such as sentences and narratives. Because we were seeking the creative origins of the language, we conservatively did not select from elements that might arguably have been drawn directly from the (albeit inaccessible) family language environment, such as expressions that resembled spoken Spanish, or signs borrowed directly from common Nicaraguan gestures. We also sought a form outside of signers’ explicit knowledge of their language, that we had never seen described by Nicaraguan signers, even during sign language instruction. We chose a grammatical device common to sign languages but not found in spoken languages: spatial modulation.

2.1. *Spatial modulation*

Most signs can be produced in an unmarked form in a neutral, central location in front of the signer’s chest. However, one can choose to spatially modify a sign, producing it with a movement toward or away from a particular non-neutral location. These modifications, or *spatial modulations*, are typical devices in the grammars of sign languages, and have been found in all sign languages studied to date (Padden, 1983; Supalla, 1982, 1995). Functionally, spatial modulations resemble the grammatical endings appended to words in spoken languages. In sign languages around the world, spatial modulations have been observed to serve several grammatical functions, including the indication of person and number, the provision of deictic, locative, and temporal information, and the marking of grammatical relationships, such as a verb’s subject and object (Fischer, 1973; Klima & Bellugi, 1979; Padden, 1983). For example, in American Sign Language (ASL), nouns are marked as definite and specific by being indexed to particular non-neutral locations; verbs then agree with their noun arguments by referencing these same locations. An “agreeing” verb would typically begin at the location assigned to its subject, and move to the location assigned to its object (Padden, 1983; Wilbur, 1987).

Although deaf Nicaraguans in the 1970s were never exposed to a developed grammar that included spatial verb agreement, it is likely that a creative use of the

signing space to express relations between concepts was present in the gestural and homesign environment that surrounded NSL from its earliest days. Hearing people who are asked to use gestures to describe videos of objects in unusual positions, and moving along various paths, will exhibit rudiments of a spatial gestural system (Singleton, Goldin-Meadow, & McNeill, 1995). Homesigners, too, have been observed to produce signs in particular locations in the signing space to represent relationships among people, objects, and actions (Coppola, 2002; Goldin-Meadow & Mylander, 1990). Thus, spatial resources were probably candidate raw materials for deaf Nicaraguans to develop a more complex system for representing grammatical relations.

2.2. *The production of spatial modulations in Nicaraguan Sign Language*

A series of studies exploring the emergence of morphology in NSL (Senghas, 1995b; Senghas & Coppola, 2001; Senghas, Coppola, Newport, & Supalla, 1997) examined which signers produced spatial modulations and the contexts in which they produced them. One of these studies (Senghas et al., 1997), designed to examine devices for expressing argument structure, elicited a number of simple sentences that included spatially modulated verbs. As sentences from this production study were used to create stimuli for the present comprehension study, I will describe it here in detail.

The participants in the production study were eight Nicaraguan signers, four of whom were first exposed at the beginning of the Extensive Contact Period between 1977 and 1983 (referred to as the *first-cohort* signers), and four of whom were exposed later in the Extensive Contact Period, after 1983 (referred to as the *second-cohort* signers). Each participant watched 32 videoclips of simple live-action events, such as a woman tapping a man, or a man giving a cup to a woman, and signed a sentence corresponding to each event.

An initial examination of the word order patterns in these sentences has revealed that the first cohort expresses the relations among elements in the sentence with a small set of basic word orders. Interestingly, these sentences typically include a verb for each animate argument, and thus include two verbs for many single-action events, as in MAN GIVE WOMAN RECEIVE.³ These noun-verb-noun-verb word orders effectively indicate the different semantic roles (such as agent, patient, or recipient) in an event by having only one role associated with each verb. There is evidence of an expansion of word orders in the signing of the second cohort, and as a result semantic roles were not always unambiguously indicated by word order in the sentences of these younger signers.

This ambiguity motivated us to examine spatial modulations in the verbs in these sentences. Perhaps certain semantic roles were being indicated with spatial

³ Following the conventions for sign language transcription and notation, words written in upper case letters are used as glosses representing the approximate English translation of a sign.

modulations rather than word order. In the signing of both cohorts, many verbs were modulated toward the right or left of the signer. We examined whether these movements were related to the semantic roles associated with the nouns in the sentence. In particular, we examined whether the movement toward a particular location indicated the patient or recipient in the event. For example, if we consider all of the events that were expressed with verb movement to the *right*, how often was it the case that the person to the *right* was the patient in the event? When a person to the *left* was the patient, was the verb more likely to be produced with a *leftward* movement?

Our primary interest was not so much in whether these movements were to the right or to the left; rather, we wanted to know if there was a consistent pattern underlying the mapping of spatial modulations across the set of sentences produced by each signer. The videotaped stimuli all presented a man and two women, seated at a table, engaging in simple activities (such as coughing, tapping, and giving an object). A signer representing these events in space could do so using one of two mappings, illustrated in Fig. 1. Consider the event in which a woman gives something to a man who is on the *left* (presented in Fig. 1 with a frame from the video of the event). One layout, in signing the sentence, positions the man to the signer's *left*; the other layout positions the man to the signer's *right*. We refer to these layouts as *unrotated* and *rotated* representations, respectively.

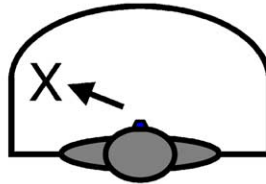
For each signer, we examined all of the sentences that described events involving two characters. Each verb that included a spatial modulation was coded with respect to whether that location corresponded to a rotated or unrotated layout. For example, for every event in which the man to the left takes a patient role, a modulation to the left would be coded as an *unrotated* layout and a modulation to the right would be coded as a *rotated* layout. To determine whether spatial modulations were being used productively, and potentially, grammatically, we examined whether individual signers, and each cohort as a group, used a consistent spatial layout in their spatial modulations across their responses.

As can be seen in Fig. 2, the signers from the first cohort used both possible spatial layouts, and were not consistent in their use. Two of the first-cohort signers each produced an internally consistent mapping, but their systems differed from each other. If they were intending to indicate semantic roles, it seems they would misinterpret each other's signing. The other two first-cohort signers did not modulate their verbs to either layout consistently, instead using both layouts interchangeably. Taking these four signers together as a group, it is unlikely that this first cohort productively applies spatial modulations to the function of indicating semantic roles.

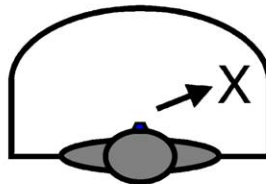
The second-cohort signers, in contrast, consistently used a single layout for producing spatial modulations in their sentences. Furthermore, all four, as a group, applied the same rotated representation. This pattern was produced consistently across sentences and across signers, suggesting that spatial modulations are being used as a shared grammatical element among this age cohort.



stimulus event:
a woman giving a cup to a man



unrotated representation



rotated representation

Fig. 1. Illustration of unrotated and rotated representations of a giving event. The event is represented by a frame extracted from the video stimulus (in the experiment this was presented as a live-action video on a small monitor placed at arm's length from the signer); the diagrams beneath the depiction of the event represent the signer and the signing area as viewed from above, with a semi-circle representing the signing space in front of the signer. The movement of the verb is represented with an arrow, and the implied location of the man is marked with an X. This location is compared with the man's location in the event to determine the rotation of the representation.

3. The limitations of production data and the need for comprehension data

The changing pattern of verb modulations observed in production, though compelling, does not quite prove that a system of spatial modulations exists in the grammar of NSL. Although informative, production data present a logical limita-

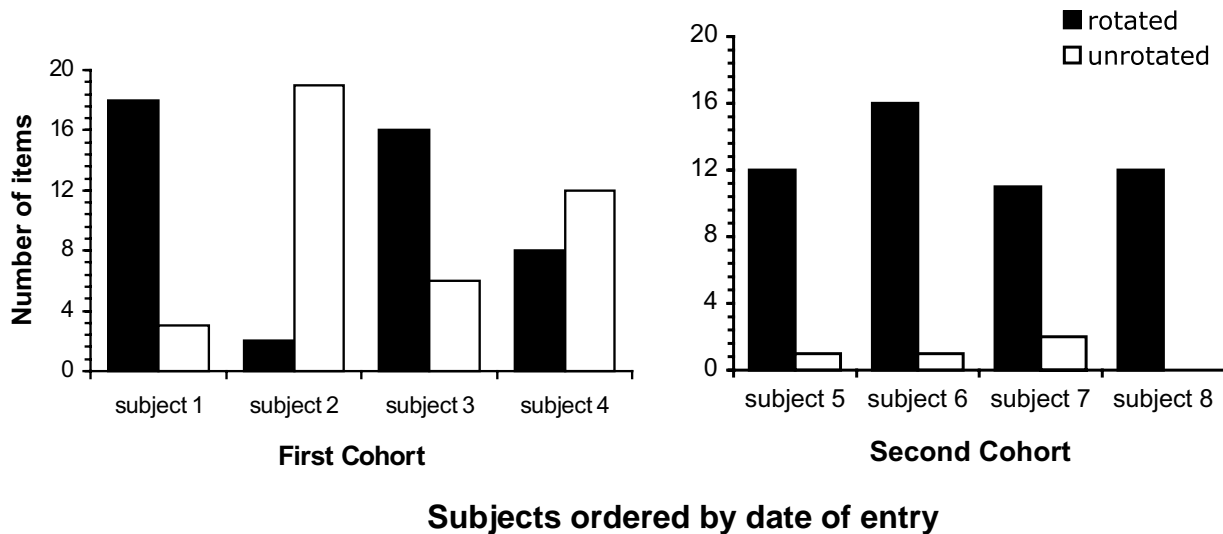


Fig. 2. Mapping of spatial modulations of verbs, relative to the layout in stimuli presented, in the sentences produced by first- and second-cohort signers. While first-cohort signers (particularly participants 3 and 4) produced verbs with both rotated and unrotated representations, second-cohort signers consistently employed only a spatially rotated representation (from Senghas et al., 1997).

tion for a linguist deciphering a grammar. One can never determine with certainty the function to which an observed form is being applied. One must infer the function given the context in which the form appears. But contexts are noisy, and present an infinite number of co-occurring potential interpretations (Quine, 1960). Furthermore, a form can have multiple functions, and spatial modulations are no exception. Some spatial modulations in NSL occur in contexts when no semantic role or specific referent is implied. For example, signers frequently shift locations to introduce new characters or topics, to indicate different points in time, or to adopt a rhythmic prosody, alternating from one side to the other (Senghas, 1995a).

In NSL, a sign might obligatorily, probabilistically, or coincidentally exhibit a spatial modulation that corresponds to some component of the meaning of a message. The mere appearance of a spatial modulation on a sign will not reveal the practice that holds in the grammar of its signer. Our goal is to identify the systematic mapping of form to meaning in a grammar; thus, it is as important where a modulation *cannot* occur as where it can occur, and it is as important what an utterance *cannot* mean as what it can mean. To have acquired the “rule” that governs spatial modulations requires both aspects. Discovering whether an individual’s version of NSL includes this mapping requires the negative evidence available only in comprehension data. Which members of the signing community attend to spatial modulations and use them to decipher the semantic roles intended by a signer?

By sorting signers of NSL into those who produce and comprehend spatial modulations similarly and those who do not, and by comparing the language environment and patterns of social contact between the two groups, we can discover the conditions under which this new linguistic element emerged.

4. Design and hypotheses

The present study compares how early-exposed Nicaraguan signers interpret spatially modulated verbs. We expect first-cohort signers, who were children in the earliest years of the Extensive Contact Period (between 1974 and 1983), to ignore the direction of spatial modulations in their interpretation of the semantic roles in a sentence. We expect second-cohort signers, who were children later in the Extensive Contact Period (between 1983 and 1990), to have a more constrained and fully systematic interpretation of the direction of spatial modulations.

For example, if the verb TAP were produced in a rightward direction in a description of an event that involved a man on the left and a woman on the right, we would expect the expression to mean either “the woman taps the man” or “the man taps the woman” to first-cohort signers, but only “the woman taps the man” to second-cohort signers. Such a difference in interpretation would definitively reveal a shift in the grammar of the language.

To ascertain whether participants considered the direction of a verb’s movement to be relevant to the interpretation of semantic role, we presented them with

videoclips of sentences that had been elicited in the production study described above, and asked them to indicate the range of interpretations possible for each sentence by selecting among pictures that depicted various versions of the event. That is, whereas in the previous production task participants were shown events and asked to sign corresponding sentences, in the current comprehension task they were shown sentences and asked to indicate corresponding events. However, using these elicited sentences as stimuli presented us with a challenge. Many of them included a word order that already made the assignment of semantic roles unambiguous, such as representing a woman tapping a man with the sentence WOMAN TAP MAN TAPPED. When word order cues and spatial modulations redundantly indicate semantic roles, we cannot tell which cue participants are using. For this reason, in order to contrast the relative locations of the characters being described, we presented participants with response-picture choices that portrayed the target event, left-to-right reversed images of the target event (with each actor in the same semantic role), and distracter events involving the same characters. Participants for whom the direction of movement in a verb is meaningful and specific should attribute spatial verbs to only one version of an event. In contrast, participants who do not interpret this contrast linguistically should accept both the original and the reversed images of an event as possible interpretations of a sentence.

5. Method

5.1. Participants

The participants in the present study were 12 Deaf Nicaraguan signers. All had entered the signing community and begun signing by the age of 6, with a mean age of 4;0 (years;months). Their date of entry ranged from 1974 to 1990, with a median date of 1984. Six of the participants entered the community between 1974 and 1983; they will be referred to as the *first-cohort* participants. The remaining six participants entered the community between 1985 and 1990; they will be referred to as the *second-cohort* participants. Participants' age at the time of testing ranged from 12;5 to 29;10, with a mean age of 20;4. All participants had previously participated in the production task from which the stimulus materials for this experiment were drawn.⁴

5.2. Materials and procedure

The stimuli consisted of a set of 22 signed sentences produced by eight of the participants (four from each cohort) 2 years earlier. The sentences had been collected in the course of a production task as descriptions of simple events, such as a woman tapping a man, and a man giving a cup to a woman. Each item consisted

⁴Data from this production task are currently under analysis; production findings from the first eight subjects to be tested were presented in Senghas et al. (1997).

of a single sentence, approximately 2 s in duration, displayed on a small video monitor at approximately arm's length.

Four sentences served as training items; these described events that involved a single person, like crying and jumping, produced with no directional movement on the verb. Eight test sentences described events that involved two people, like giving and tapping, and had been produced using spatially modulated verbs. The test sentences were counterbalanced with respect to whether their modulations were toward the left or right side, and also with respect to their spatial layout (unrotated or rotated) relative to the original events they represented. That is, in half of the sentences a man who was on the left in the original event would be indicated by the signer with a movement to the left (unrotated), and in half of the sentences that same man would be indicated with a movement to the right (rotated). (Recall that in the production study, samples of both layouts had been elicited from several different signers.)

The remaining sentences were filler items, produced either with no directional movement or with inconsistent directional movements over the multiple verbs in the sentence. The sentences were divided into two equal halves, set A and set B, with four of the test sentences included in each half. The order of the sentences was randomized within each set, with the constraint that the same signer of a sentence not appear twice in a row. Half of the participants were given set A before set B; the other half were given set B before set A.

Participants watched each sentence on a small video screen and then indicated their interpretation of the sentence's possible meaning(s) on an answer sheet. The answer sheet consisted of four pictures that depicted different versions of the events being described. These pictures were created by extracting frames from the videos that had been used to elicit the stimulus sentences during the production task. For example, one picture depicted a woman on the right tapping the shoulder of a man on the left.

For the test items, at least one of the pictures (the target) depicted the event that had been viewed by the signer producing the sentence (such as a woman on the right tapping the shoulder of a man on the left). Another picture presented the left-to-right reversed image of that event (in this case, a woman on the left tapping the shoulder of a man on the right). The remaining two pictures depicted either another moment in the target event, its left-to-right reversed image, or a distracter picture that depicted a different event.

The answer sheets for filler items were designed to give all participants reasonable opportunities to accept 0, 1, 2, or 3 pictures on the page. Two of these items included no depiction of the target event (that is, they included four distracter pictures); two of the items included only one picture of the target event (with three distracter pictures), and the remaining filler items, like the test items, depicted the target, its left-to-right reversed image, and two other pictures that depicted either another moment in the target event or a distracter picture. Importantly, the non-spatial filler items provided opportunities in which both the original image and the reversed image of an event (such as a woman tearing a tortilla) would be

likely to be considered an acceptable interpretation for all participants, regardless of their interpretation of spatially modulated signs.

As an example, in one typical trial, a participant would watch a signer produce the sentence WOMAN TAP MAN TAPPED in which the first verb included a movement to the right, and the second verb included a movement from the left. The participant would then consider the four pictures on the corresponding answer sheet, including two pictures depicting a woman tapping a man (one with the man to the left, and the other with the man to the right), one depicting a man showing a woman a paper, and one depicting a man pushing a woman. In the upper left corner of each picture, in a white box, the participant would write a checkmark (indicating that it depicted a possible interpretation of the sentence) or an X (indicating that it did not depict a possible interpretation of the sentence). In this example, since the spatial modulation is to the right, a checkmark by the picture with the man on the left would indicate that a rotated interpretation was accepted, and a checkmark on the picture with the man to the right would indicate that an unrotated interpretation was accepted.

After completing the first set of items, participants were asked explicitly, with regard to the most recently completed item, if it made any difference in which direction the verb was produced. Participants then proceeded to the second set of items.

5.3. Scoring

For each sentence, the pictures that had been indicated with a checkmark on the answer sheet were recorded as accepted interpretations. Each item was coded with respect to whether a *rotated* and/or *unrotated* layout was accepted. If both interpretations were accepted, the item was coded as reflecting an interpretation that was *unrestricted* with respect to spatial layout. (Distracter pictures were never selected.) In addition, each participant's response to the question of whether a verb's direction mattered was noted.

6. Results

As can be seen in Fig. 3, the first-cohort participants, who entered the signing community between 1974 and 1983, indicated that sentences with spatially modulated verbs could correspond to both the original and the left-to-right reversed depictions of an event. That is, they all accepted both rotated and unrotated representations. The pattern changes abruptly when we turn to the second-cohort participants, who entered the community between 1985 and 1990. These participants all consistently applied a rotated representation as they interpreted the spatially modulated verbs, and limited their acceptance of the event depictions accordingly.

The *t* tests comparing the two cohorts confirm that they do indeed differ in their interpretations of spatial modulations. First-cohort participants indicated an



Fig. 3. Interpretations accepted by first- and second-cohort participants for sentences including a spatially modulated verb, ordered by the date of each participant's entry into the community. Chance level (assuming distracters are not selected) is indicated with a broken line. While first-cohort participants, who entered the community prior to 1984, accepted both rotated and unrotated interpretations, second-cohort participants, who entered after 1984, predominantly accepted rotated interpretations only, and never accepted an unrestricted interpretation.

unrestricted interpretation for significantly more sentences ($M = 7.7$ out of 8) than second-cohort participants ($M = 0$), $t(10) = 23$, $p < .0001$. This result was due entirely to the difference in acceptability of unrotated representations. The two cohorts did not differ in their acceptance of *rotated* representations, as everyone usually accepted them (first cohort: $M = 7.8$; second cohort: $M = 7.7$), $t(10) = 0.62$, $p = \text{n.s.}$ However, they differed significantly in their acceptance of *unrotated* representations, the first cohort typically accepting them ($M = 7.8$) and the second cohort practically never accepting them ($M = 0.3$), $t(10) = 27.9$, $p < .0001$. Evidently, only the second-cohort signers were using spatial modulations to assign the character on one side (and not the other) to the patient role.

Note that the categorical nature of this result is not a consequence of the design of the experiment. One can just as easily consider date of entry to be a continuous variable. As is evident in Fig. 3, while the participants' dates of entry progress gradually from 1974 to 1990, the change to a restricted interpretation begins abruptly with the participant who entered in 1985.

All participants accepted both original and left-to-right reversed images for filler items that involved a single character in a non-directional event, such as a woman tearing a tortilla, and a man crying. Thus, the more constrained selections do not reflect a general resistance to selecting two or more different pictures for a single sentence.

When asked halfway through the task whether the direction of movement in a verb made a difference in their selections, the first-cohort participants all responded that a verb could be signed to the left or the right without changing the meaning of the sentence. In contrast, the second-cohort participants all responded that the direction in which the verb was produced did make a difference. Interestingly, among those who gave more elaborate responses, the degree to which it mattered increased as the participants' ages decreased. The oldest and third-to-oldest of the second-cohort participants (who were 16 and 15 years old) added that the picture corresponding to an unrotated depiction would be a possible choice for some people, but that they strongly preferred the pictures that corresponded to a rotated interpretation. The second-to-youngest (who was 12.5 years old) responded that older signers will often sign the other way, since they "can't always remember" which way the relative positions were originally assigned. The youngest participant (who was 12 years old) insisted that the picture that corresponded to a rotated interpretation was the only acceptable option, and the unrotated depiction could never correspond to the given sentence. ("If you wanted to say that, you would sign it here on the other side," he explained, rolling his eyes as if it were unreasonable to even ask.) Apparently, the change in the interpretation of verb modulation was taking place over the latter half of the 1980s, during this second cohort's acquisition of the language.

These results are particularly striking when we consider that many of the sentences used as test items had originally been produced by first-cohort signers who did not follow the new rule. Because stimulus sentences were counterbalanced with respect to spatial modulations, half of the items technically corresponded to an unrotated representation, and half to a rotated representation. For the first-cohort

signers, as we now know, apparent spatial modulations were not intended to specify a link to the patient in the event. Nevertheless, the second-cohort signers, when observing these sentences, interpreted them all as if the modulations were meaningful, consistently using a rotated representation. Thus, on half of the items, they were selecting the left-to-right reversal of the event to which the original signer actually referred. Fully half of the time, the younger participants systematically misinterpreted sentences produced by the very people from whom they had learned their language as children.

7. Discussion

In previous work examining verb production in NSL (Senghas, 1995a; Senghas & Coppola, 2001; Senghas et al., 1997), different patterns in the production of spatial modulations had been observed. Signers who were first exposed to the language in the earliest years of the Extensive Contact Period, up to 1984, produced modulations sporadically and inconsistently, and signers exposed later in that period, from 1984 onward, produced them systematically and consistently. The present comprehension data reveal that this difference reflects a new grammatical structure underlying the use of these forms; the change does not reflect a mere increase in the frequency of an already present structure. The new structure is evident in the restricted interpretation of spatially modulated verbs by signers who were first exposed to NSL as children after 1984. Signers who were first exposed to NSL as children before that time, and who were entering adolescence by the mid-1980s, do not exhibit this restriction. Taken together, the present-day patterns of NSL production and comprehension indicate that this grammatical use of spatial modulations was established over the course of the 1980s, by sequential cohorts of child learners.

The new meaning attributed to these forms does not reflect a broader, more general application. Instead, a variation that was previously undifferentiated (signing to one side or another) has become differentiated (one side now differs from the other), and the meaning of each modulated sign has correspondingly become more specific. The particular innovation in the language was therefore not the act of signing in space; it was the constraint on how space could be used. This innovation not only limits the way signs can be produced; it limits what the signs can mean, and in this way it makes the grammar more specific in its reference. For example, consider a sentence in which *see* and *pay* are both produced to the left. To signers who don't have the new structure in their language, the sentence could mean that one person was seen and another paid, or that a single person was both seen and paid. Signers who have the structure accept only the second, more restricted interpretation. For them, the first reading is not merely unlikely, it is also ungrammatical.

Such specific, consistent form-function mappings, shared by a community of users, make up the grammar of a given language. Until forms are used consistently and are shared with other members of the language community, they serve no

grammatical function, and are meaningless. It is such a consistency, at the community level, that was created by young Nicaraguan signers when they changed the way they produced and interpreted spatial modulations. In creating consistent form-meaning mappings, they are creating a new grammar where there was none.

Because this change and growth in the language was so rapid and so recent, many of the signers in the community today continue to use a version of the language that lacks the new structure. These signers are currently adults in their late-20s and early-30s. They have presumably produced what are now “ungrammatical” forms since they were children in the late-1970s and early-1980s, providing them in the language environment to others in the community even to the present day. This means that the children who came into the community later, after the mid-1980s, are currently rejecting sentences of a type they have seen all of their lives, and have constructed a version of the language that is different from the one that was modeled for them in childhood.

However, this new version of the language is not unrelated to its model; it is derived from it. Forms that exist in free variation or with some other function in the language of the first cohort were available for the second cohort to use as raw materials for creating new form-function mappings. If the first stage were not necessary, all of NSL would have appeared in a single sweep, instead of being built cohort by cohort. *Slobin (1973)* attributes some of the developments observed in early language acquisition to a similar process by which “new functions are first expressed by old forms”. In the case of NSL spatial modulations, the “old” form is itself new enough that it may have had no previous contrastive function at all, or had few meaningful variations.

Where did the spatial form itself originate? It may be that a more concrete use of space was a precursor to this more abstract use of space for indicating relations between signs. The movements used in indicating the relationships between people and actions appear to be metaphorically linked to physical spatial relations (*Taub, 2001*). For example, the movement toward a location with the verb GIVE indicates the recipient of a giving event. Perhaps child learners of NSL first developed conventions for physical, locative descriptions, and then used these to bootstrap into devices for grammatical relations. To explore this possibility, ongoing work is examining the devices used by signers from each cohort to describe the positions and locations of objects.

Whatever its raw materials, this important change in the grammar of NSL came about when those who were children in the mid-1980s got their hands on it. Evidently, the language abilities that children possess early in ontogenetic development enabled young signers to newly differentiate a contrast in form and apply that contrast systematically to a new contrast in meaning, thereby generating a form-function mapping not observed in the language of their adolescent models. This new grammatical feature soon spread to others who were also young. In every peer interaction, the influence was bi-directional. That is, each child affected, and was affected by, his or her age peers, resulting in horizontal convergence across members of the age cohort.

However, along the vertical dimension, signers did not converge. Deaf adolescents and adults at the time, who had been signing since they were young children, did not adopt the new feature, despite their constant contact with younger signers. Thus, the feature did not spread from the second cohort up to the first cohort. In introducing this change, children diverged from adolescents and adults; although seeded by the grammar of the older signers, they did not faithfully reproduce it. As a result, while the pattern of influence along the horizontal dimension was bi-directional and matching, the pattern of influence along the vertical dimension was unidirectional and non-matching.

What happened in the mid-1980s that led to this abrupt change in the language? This was not a time when a new school was established, or a new community was initiated. The beginnings of extensive peer contact had occurred years earlier, in the mid- to late-1970s. The change taking place over the mid-1980s was a gradual but important one: the first children to have engaged in extensive peer contact were maturing, and entering adolescence. As children, they had begun to build a system that was richer than what they had been exposed to in their family environments. As adolescents, they were now passing this emerging language down, for the first time, to a new entering cohort of children. Although this language did not yet include a system of spatial modulations, it evidently included the seeds that enabled the children who were exposed to it to together derive such a system.

Thus, the adolescents of the mid-1980s played an important role in the development of spatial modulations, even though they do not exhibit the form themselves. In a sense, they passed on a construction of which they had no knowledge, implicit or explicit. They certainly did not explicitly teach the construction to the children. But the children who learned from them nevertheless acquired the construction with exposure to the system that the adolescents themselves had built up, so far, while children. Thus, in learning the language as children, neither cohort matched the frequencies and forms of the model provided to them. Instead, they changed the language in a way that reflects the particular manner in which children commonly take in and organize linguistic information.

The reproduction and evolution of this language came about only after there were opportunities for extensive intergenerational contact. Logically, this contact must be equivalent in both directions along the vertical dimension. Adults are in contact with children just as much as children are in contact with adults. The fact that they respond differently to the information shared during that contact indicates that the pattern of unidirectional, non-matching vertical influence is due to the difference in the ontogenetic stages of the learners, not to a difference in exposure.

This pattern of changing influence on the language with age corresponds to a well-documented change in the ability to learn language, and suggests a common process. Children surpass adults at learning language, even though adults are superior at mastering other complex information (Johnson & Newport, 1989; Newport, 1990). Apparently, the manner in which individuals learn language changes as they mature, with language stabilizing in adolescence and adulthood.

Young children have the ability to develop new, more specific form-function mappings out of generally applied forms from the environment. Language emergence and evolution requires this ability, and therefore requires children.

In addition to children's learning abilities, language emergence is equally dependent on sociocultural conditions that enable both peer and intergenerational contact. That is, children need to be in contact both with other children and with adults. As the first Deaf Nicaraguans to have had extensive peer contact entered adolescence, they gained the self-determination that enabled them to establish extensive intergenerational contact with those who followed. Although this change was gradual, it defines two qualitatively different sub-periods during the Extensive Contact Period. The first few years, from the late-1970s until the mid-1980s, was a period of extensive peer contact. From the mid-1980s up to the present day is a period of extensive peer and intergenerational contact.

Once intergenerational contact is in place, and child learners are available, the conditions are present for language development and perpetuation. Under these conditions, the following sequence of the emergence of a new feature can take place:

- (1) Meaningless variations of a form arise in a language; they are semantically equivalent and functionally undifferentiated.
- (2) Young children take up a previously meaningless variation in a form, and attribute to it a contrastive meaning or function.
- (3) The new form-function mapping is then acquired by peers who are also young children, but not by contemporary adults.
- (4) As the children age into adolescence, their role shifts from one of acquiring and changing the language, to one of modeling the changed language, with its new form-function mapping, to a subsequent cohort of children.

As a result of this process, each new cohort of learners will converge with their peers, but will not faithfully converge on the model provided by the previous cohort. Constructions that have "taken hold" in the language will be present in the language of all those who were exposed to them, or developed them, in childhood. Therefore, those elements that are missing from an individual's version of NSL most likely emerged after that individual had already reached adolescence. Conversely, the set of constructions present in the language of each individual represent the total contributions of that person's age cohort and its predecessors. As a result, constructions are distributed across signers today like rings on a tree. We can date when each construction entered the language by noting the year in which each individual who produces and understands it first entered the signing community as a child.

In the early stages of NSL, this process has propelled the language along a path of increasing complexity. Along the historical timeline, the community transforms the language environment, which, in a richer form, stimulates the community, which then transforms the language further. This timeline interacts in an important way with the ontogenetic timeline of individual development. Within each individual,

the changes to the language are implemented primarily in childhood, and the language is passed down to others in adolescence and adulthood. This results in a lag of an age cohort between the time when a form first appears and when it will spread to the next cohort, if it is to survive in the language.

Note that an individual's potential contribution, in both sociocultural and linguistic domains, changes over the course of ontogenetic development. Early in life, individuals can best learn and transform their own language, and influence the language of peers. Later in life, individuals can best influence the structure of their social community, and provide the fertile conditions under which their language can grow. Ironically, social capacity (which develops later) is required to seed and stimulate the language capacity (which is available earlier). For this reason, no single age cohort can progress through the developmental stages in the order necessary to create a new language in a single pass. The birth of NSL awaited a community of sequential age cohorts, each creating the interaction that provided the raw materials for younger, new arrivals, year by year, to sculpt into grammar.

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