CHAPTER

3

Connecting Language Acquisition and Language Evolution: Clues from the Emergence of Nicaraguan Sign Language*

Ann Senghas
Barnard College, Department of Psychology, 3009 Broadway, New York, NY 10027, asenghas@barnard.edu

Languages are intricately patterned abstract systems, shared by speakers within every social community. Where do their patterns originate, and why do some appear to be universal, recurring in language after language? How is this complex structure retained over multiple generations within a language community? The ease and accuracy exhibited by children learning language should surprise us, given the intricacy of what they learn. Language systems have multiple levels of abstract, hierarchically

* This work was supported by Grant No. R01 DC005407 from the National Institutes of Health/National Institute on Deafness and Other Communication Disorders.

organized symbolic information, capable of generating an infinite number of expressions. Linguists can work for years documenting a language's grammar and still not capture all of it. Adults learning a new language can fail to acquire it completely, even after several decades. Even so, every individual person masters a complete language, without explicit study, in the first few years of life. If we take a language to be an adaptive system, we can explain this ease. Under this view, human language learning and use shapes a language as it is passed from one learner to the next, producing a patterned system that is customized to the human learner. I argue that it is child learners, in particular, that drive this customization. In other words, languages have been naturally designed, after generations of child acquisition, to be easily learned by children in their earliest years. Furthermore, I contend that while the iterative nature of this process is necessary for acquisition to progressively shape language, it is not itself the source of structure. Rather, fundamental aspects of children's learning abilities provide the machinery to the system of replication by which a language evolves. These consist of shared tendencies in combining, dividing, and mapping symbolic information. The ultimate goal is to discover the specific nature of these fundamental characteristics of learners by capturing their imprint on the languages they create.

We can view every language that exists today as an evolving, dynamic system that has adapted to its learners as it was imperfectly and repeatedly recreated over generations (Deacon, 1997; Keller, 1995). This view of language as an adaptive system treats a language as an organism subject to evolutionary principles. It is on a massively different timescale than the origin of language capacity in humans (though Christiansen and Chater (2008) presents them as a single process), and of course the two interact; as language capacities emerged, they, in turn, would have shaped the structures of languages (Pinker & Bloom, 1990). Even in modern times, languages change over the centuries as they are passed from one generation to the next, and remnants of earlier variants remain in modern forms. We can consider this process to be one of evolution, with some traits of a language being "selected" and successfully passed down, while other traits are repurposed or disappear altogether (Hurford, 2012; Tomasello, 1999, 2003).

If we are to adopt this evolutionary view of language in more than a metaphorical sense, we must consider seriously the mechanisms of

reproduction. In the case of languages, reproduction occurs when a language is learned; a language reproduces once in the lifetime of each individual learner. Children observe language being used, adopt a structure as close as possible to the observed language, and reproduce the language in their own communication. Accordingly, no feature, no matter how useful or elegant, will survive in a language if children are not inclined to acquire it. A change in a language suggests that, for learners, the deviation from the past variant may have been more easily acquired, or more naturally inferred, based on the language model that they observed.

We can look to acquisition not only to explain how language changes, but also to explain how a language retains its aspects over generations. Individual speakers from one generation cannot pass a grammar, whole cloth, to their children. All they can do is display their language, and allow children to apply their learning mechanisms to this input to weave a similar structure of their own. How do children convert a stream of language percept into an internal, highly structured abstract system? In the following pages I will suggest that they must coordinate fundamental mechanisms to carry out this transformation. These mechanisms include the ability to map or align symbolic information across different representations, as well as the ability to combine and divide elements in a coordinated manner to achieve this alignment.

A child learning a language is not presented with instructions or translations. Utterances occur in a communication context. As each sentence is presented, the child must surmise its meaning, linking it to some content or event in the world. To do this, the child must create correspondences across levels of analysis, such as between a form and its meaning, or between a variable and the set of values that it can represent. Mapping, node for node, motivates the analysis of an utterance into its components. For example, if an utterance is mapped to an event, each component of the utterance must correspond to an encoded component of the event. However, this mapping does not occur directly between parts of the utterance and parts of the world. There are infinitely many facets of an event, and not all of them will be linguistically represented. Furthermore, a single event can be described from different perspectives, yielding different meanings to the words that describe it. For example, *a tiger chasing a boy* and *a boy fleeing a tiger* could refer to the same event, but the words *chase*

and *flee* have quite different meanings. Each refers to a different construal of the same event. Thus, sentences do not map onto events; they map onto construals of events. Even very young children are not confused by this distinction, and are highly sensitive to the linguistic cues that indicate the intended perspective (Fisher, 1994; Fisher, Hall, Rakowitz, & Gleitman, 1994). As children interpret a sentence, they seek to align recognized components of the sentence with components of the construal. For an event construed as *chasing*, they will identify a chaser, an action, and a chase-ee. If their understanding is incomplete, and they cannot successfully align the utterance with a construal, I suggest that they will need to make adjustments to either their analysis of the utterance or the construal. To do this, they divide and recombine parts of their existing representations to achieve a better correspondence between form and meaning.

Combining and dividing are complementary processes that together enable the hierarchical structures of a language to be discovered and rebuilt. Like gestalt principles, they guide the language learner to find linguistic objects, and their relationships, within the utterance stream. Combining brings elements together to form a single structural unit. This process can be repeated, resulting in nested structures. However, a learner cannot combine elements before learning the combinatorial patterns in the language. This is where dividing comes in – dividing breaks down a single larger component into multiple smaller components. This enables the learner to isolate the basic elements in a language, and also discover the patterns for recombination.

This combining and dividing happens at every level of language, right down to identifying individual elements within a stream of percept. Imagine, for a moment, the repeated two-tone sound of an ambulance siren, or the clip-clop of a trotting horse. If alternating elements contrast in intensity, we mentally divide the stream into pairs of trochees, with the strong element first: *LOUD-soft, LOUD-soft*. In contrast, if alternating elements differ in duration, we mentally divide the stream into pairs of iambs, with the long element second: *short-LONG, short-LONG*. These iambic and trochaic principles were first noted in music (Bolton, 1894), but have more recently been studied in language (e.g., Hay & Saffran, 2012; Morgan, 1996; Nespor et al., 2008). Of course, combining and

dividing processes operate at multiple levels of analysis, not just perceptual parsing. For a child parsing a stream of language, patterns that correspond to initial biases would be more easily learned, and units detected or constructed through these processes could later be identified in other combinations, leading to the learning of regularities within the specific language, such as the order of sounds within words, and words within phrases.

As a language is passed down, it is subject to these combining, dividing, and realigning mechanisms in every new learner. This process of reproduction is not exact, and each instance of learning is an opportunity for a language to change. Naturally, combinations that are difficult to break down, or mappings that are unintuitive, are likely to change or disappear. Furthermore, because aspects of a language are advantageous to the extent that they are shared within a linguistic community, any shared intuitions will be favored. Even slight biases in the ease of learning certain patterns or word-meaning mappings could have a significant impact on a language over multiple iterations of learning, as long as those biases were shared (Kirby, Dowman, & Griffiths, 2007).

When examining the structure of a modern spoken language, we cannot know whether any given feature is the inevitable outcome of language-learning mechanisms, or merely compatible with them. All languages undergo change as they are imperfectly and repeatedly recreated over generations. These changes need not represent "progress"; variation does not necessarily mean an increase in complexity or expressive power. Even so, the course of change in a language provides clues to the nature of the minds that engendered it. Over the long term, the nature of the changes can reveal common predispositions of learners, from the patterns of sounds that make up words, to the meaning components that make up an event. In the case of most languages today, the system has been passed down over millennia, through generations of learners, and in the process has been shaped so as to be highly learnable (Christiansen & Chater, 2008). Consequently, the input highly resembles the output, and the influence of any one learner is immeasurable. For this reason, we turn to a very young language, in its earliest stages, where changes to the system are much more discernible.

CHANGES IN AN EMERGING SIGN LANGUAGE

In Nicaragua, a sign language has arisen recently enough that its first stages can be observed; indeed, its originators are still living (Kegl & Iwata, 1989; Senghas, 1995). An advantage offered by this early sign language is that the input to the system is natural gestural communicative behavior, but is not a rich language shaped by generations of learning. From that origin, the rapid emergence of highly structured language as it was passed from learner to learner has yielded measurable changes in every domain.

Nicaraguan Sign Language (NSL) has its origins in Managua, Nicaragua, in the 1970s, when rapidly expanding day-school programs in special education brought deaf children and adolescents together in numbers greater than ever before. Before that time, deaf children in Nicaragua did not have full access to any developed language. They could not hear the Spanish spoken around them, and there was no local sign language available. Societal attitudes kept most deaf individuals at home with hearing family members, and the few schools and clinics available served small numbers of children for short periods with no contact outside school hours (Polich, 2005; Senghas, 1997). Thus, deaf Nicaraguan children had minimal contact with each other, and no contact with deaf individuals older than themselves. Previous work has documented that children in this situation often develop simple gesture systems, called homesigns, to communicate with hearing family members and friends (Coppola & Newport, 2005; Feldman, Goldin-Meadow, & Gleitman, 1978; Goldin-Meadow, 2003). In this context, no shared sign language emerged, evidenced by the lack of such a language in today's adults over the age of 55.

Deaf enrollment in the new programs comprised approximately 50 students in 1977, growing to over 200 by 1981, and increasing gradually throughout the 1980s. Although teachers emphasized learning to speak and lip-read Spanish, students spontaneously began communicating within their peer group using various gestures and homesigns, as they interacted socially on school buses, in the schoolyard, and in their homes. Before long, they were converging on a shared system, and NSL was born. The language continued to develop and change as new waves of children entered the community each year, typically at the preschool level, and

learned to sign by socializing naturally with the older children. Graduates of the school have maintained social contact into adulthood, establishing social and athletic programs for deaf adults, celebrating major holidays together, even marrying other deaf people and starting new families together. Today, NSL serves as the primary daily language of approximately 1,500 deaf people, ranging from 4 years of age to the mid-50s.

This is not an unusual history for a sign language. Other languages have originated in a school context, and been passed from student to student ever since. What is special about the Nicaraguan case is that it occurred recently enough that the originators of the language are able to participate in documenting it, and that by observing differences across age cohorts today, we can discern patterns of growth and change as the language developed through its earliest stages.

Decade by decade, as each wave of children acquired NSL and moved on to adolescence, changes in the language were generally passed on to newer, younger children in subsequent years, and not taken up by the older signers who had originated the language. That is, changes in the language appear to be transmitted unidirectionally, from older to younger, with the youngest members of the community exhibiting the most recent developments. To capture these changes, we systematically compare groups of signers based on the year that they entered the new community and learned the language. What we refer to as the *first cohort* of signers entered within the first decade, before the mid-1980s, by which time NSL had been learned by about 300 individuals. A *second cohort* acquired NSL in its second decade, by which time about 600 individuals had learned it. A *third cohort* acquired NSL in its third decade, by which time about 800 individuals had learned it. Of course, these cohorts are not discrete bands, and there is interaction throughout the multigenerational community. Much of the content of NSL is shared by all users of the language across the community, and we cannot know at what point such shared content emerged. However, systematic differences between age cohorts today reflect changes to the language as it was created, passed down, and relearned (Senghas, 1995; Senghas & Coppola, 2001).

How does such a new language begin, and what is first to develop? Some might expect that a language begins with the creation of words to refer to common, shared concepts, followed by the creation of structured rules

to connect those words into expressions. Instead, I will argue that words and grammar arise together, as learners with similar tendencies analyze and recombine streams of continuous expressions, dynamically realigning them with potential construals of meaning. In this way, even though the first utterances may not be structured in a language-like way, the words and phrases that derive from them are.

CHANGES IN THE STRUCTURE OF EXPRESSIONS FOR MOTION EVENTS

One line of evidence has focused on changes in expressions of motion events, from holistic to segmented signing. Consider a motion event, such as someone running out of the house. Such an event includes a manner of movement (running) and a path of movement (from inside the house, to outside the house) that are inseparable, simultaneous parts of the event. It would not make sense to ask which came first, the manner of movement or the path; they are two aspects of a single event. And yet, languages around the world construe such motion events as a combination of manner and path components, representing the two aspects of the event with separate elements in a sentence (Talmy, 1985). For example, English tends to combine a verb expressing the manner (*run*), followed by a term indicating the path (*out*) to build a combinatorial construction (as in "he *ran out* of the house"). Spanish, similarly, expresses manner and path with separate elements in the sentence, though they are assembled into a different structure: the main verb tends to express the path (*salir*; to exit), followed by the manner (*corriendo*; running) to build a combinatorial construction such as "*salió corriendo* de la casa" (he *exited running* from the house). In both of these examples, the construal of the holistic motion event has been separated into a manner element and a path element to repackage it into a linguistic expression.

How is such information bundled in descriptions of motion events in a newly emergent language? To answer this question, we showed a cartoon to hearing and deaf Nicaraguans and videotaped them as they narrated the story. The cartoon included several motion events, such as one in which someone rolls down a hill (Figure 3.1). Note that this event includes a manner of movement and a path of movement that occur inseparably in

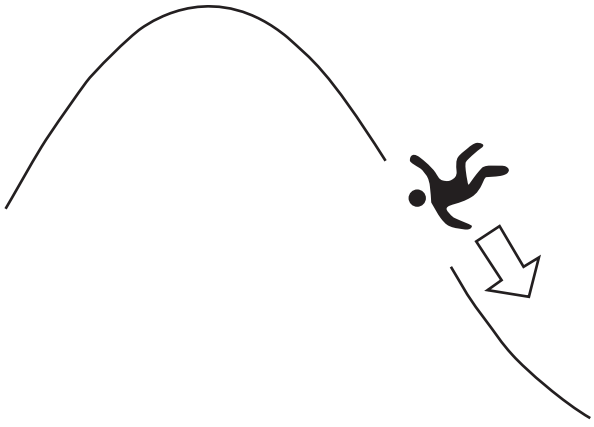

Figure 3.1 A schematic of a rolling event; manner and path of movement occur simultaneously and inseparably.

the world – one simultaneously engages in rolling and descent. We found that hearing Nicaraguans who are gesturing naturally while speaking Spanish will produce gestures in which the manner and path are inseparable, just like in the world: the hand simultaneously makes a bouncing or circular movement while moving downward (Figure 3.2). They produce this single gesture even though the two aspects of the event are separated

Figure 3.2 Manner and path expressed simultaneously. In this example a hearing Spanish speaker describes a character rolling down a hill with a bowling ball in his belly; the gesture shown naturally accompanies his speech. Here, manner (wiggling) and path (trajectory to the speaker's right) are expressed together in a single holistic movement (from Senghas, Kita, & Özyürek, 2004).

in the accompanying speech. Such a gesture is an iconic analogue of the event; its internal structure parallels the structure of the event in the world. Since rolling and descending happen simultaneously in the world, they appear simultaneously in the gesture. Thus, the mapping is holistic; the entire gesture represents the entire event.

These are the kinds of gestures that signers from the first cohort must have seen being used around them every day, as they were first creating NSL. In their own signs, we observed a similar iconic, holistic movement that referred to the entire motion event (Senghas et al., 2004). Additionally, about half of their expressions included, along with the holistic sign, a simpler manner-only or path-only sign (Figure 3.3) (Senghas, Özyürek, & Goldin-Meadow, 2013). In these expressions, one aspect of the motion event, here, the rolling manner, has been separated from the event. It corresponds to its own element in the utterance, in this case, a ROLL sign. However, the expression of the relationship between the manner and path of movement still reflects their relationship in the world; manner and path are expressed simultaneously in a single, holistic ROLLING-DOWN sign.

As we turned to the signing of the second and third cohort, we found that motion event expressions had been transformed into fully segmented sequences of manner-only and path-only signs (Figure 3.4). In this newest form of motion event expressions, some of the analogue, iconic structure of the utterance has been sacrificed, since the rolling and descending occur

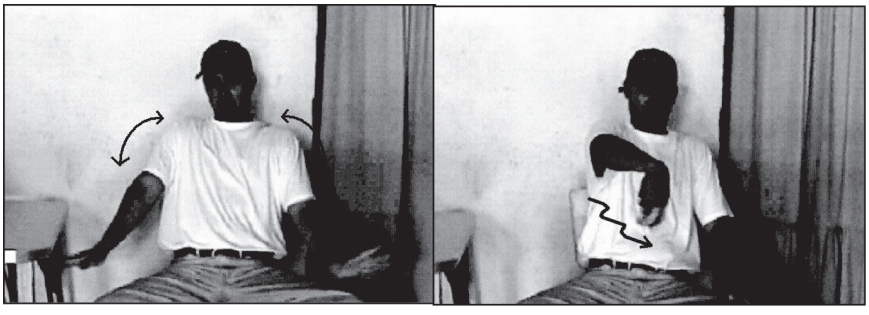

Figure 3.3 A first-cohort NSL signer describes a character rolling down a hill with a bowling ball in his belly. He first produces a body gesture for the side-to-side waddling manner, followed by a gesture conflating both the waddling manner and the forward path (from Senghas et al., 2013).

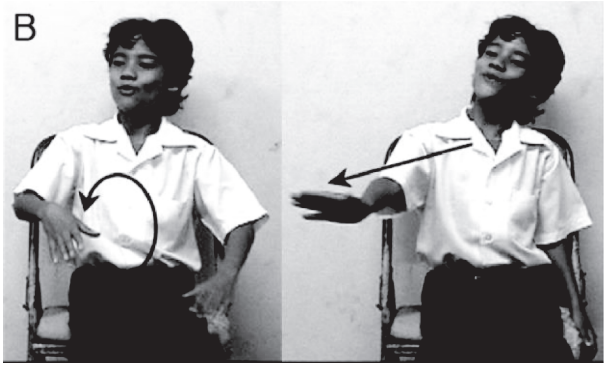

Figure 3.4 Manner and path expressed sequentially. A third-cohort signer describes a rolling event in NSL. Here, manner (circling) and path (trajectory to the signer's right) are expressed in two separate signs, assembled into a sequence (from Senghas et al., 2004).

inseparably in the world, but separately in the utterance. The holistic ROLLING-DOWN sign has been reanalyzed, and divided into two more elemental signs: one a circular movement, the other a downward trajectory. The motion event has been correspondingly divided into a manner of motion and a path of motion. And finally, a realignment and remapping linked the new signs to the new meanings, completing the production of new signs for ROLL and DESCEND. The two new signs could now be combined in a string to describe an event in which a character rolls down a hill. As it stands alone, the new utterance might seem less efficient, since two signs are needed to express something previously described with one sign. However, the processes of dividing, combining, and realigning have yielded a system that enables signers to generate expressions describing a greater variety of motion events with fewer lexical items, since basic manners of movement (e.g., rolling, climbing, running) can now be combined with basic paths (e.g., upward, downward, zigzag).

Over a few generations of learning, Nicaraguan signers produced a language that was quite different from their starting point. They reanalyzed expressions in which manner and path were produced simultaneously, turning them into sequences of simple manner and path units. One might ask whether this process of segmentation, repeated over many generations, would eventually transform all language into multisegment, sequenced strings of signs. Perhaps due to processing limitations or other factors,

learners have a bias against the simultaneous production of manner and path of motion. To address this question, we examined motion event expressions produced by signers of a mature sign language from Spain, Lengua de Señas Española (LSE). We presume that when it originated centuries ago, LSE, like NSL, drew from holistic gestures used by hearing people around them to describe motion events. When we elicited motion event descriptions from deaf native signers of LSE living in Madrid and Seville, we discovered that, unlike the recent cohorts of Nicaraguan signers, LSE signers do not tend to generate segmented expressions, and are most likely to produce manner and path simultaneously in a single complex sign (Senghas & Littman, 2004).

If non-signers' gestures, NSL, and LSE can be taken to represent stages of language emergence, the pattern of results might initially suggest a U-shaped trajectory of development, from simultaneous to sequential to simultaneous. However, a closer look reveals that the simultaneous movements are not all the same; while the co-speech gestures and early NSL signs were more holistic, there are combinatorial processes behind the LSE signs. Sign languages are subject to pressures that favor simultaneous combinations of elements, taking advantage of the signing space and multiple articulators, including the hands, torso, and head. Such combinations were evident in many of the LSE signs, as in a rolling manner expressed with one articulator and downward path with another, produced simultaneously. In other expressions, manner and path were combined into a single, complex movement, indistinguishable from a holistic gesture for someone unfamiliar with the grammar of the language (Figure 3.5) (Coppola & Senghas, 2017). One cannot know, examining a single utterance extracted from its linguistic context, whether one is looking at a holistic representation or something with internal combinatorial structure. Only by identifying the same units reassembled into different utterances can one discover the combinatorial patterns. It appears that child learners treat their language input, whatever its source, as if it has been created by a combinatorial linguistic system. Accordingly, children learning LSE today will not convert its simultaneous constructions into sequential, segmented signs, because the language has systematic combinatorial structure that has evolved to be discoverable by child learners. Today's learners do not create new joints and seams, since they can readily find the ones that are already there.

Figure 3.5 Manner and path expressed simultaneously. An LSE signer describes a character rolling down a hill with a bowling ball in his belly. Here, manner (wiggling) and path (trajectory forward and downward) are expressed simultaneously in a single movement (from Coppola & Senghas, 2017).

This cross-linguistic analysis suggests that the path from gestures to sign language begins with holistic expressions, which become partially segmented, then fully segmented, and then finally recombined to build complex expressions. The output language of each generation does not faithfully reproduce the input, nor does it fall back on some common default blueprint. The process is one of progressive realignment between motion events in the world, construals of the temporal aspects of those events, and utterances that map, part for part, to those construals. These changes come about through dividing and combining processes available to every learner.

THE GRAMMATICALIZATION OF POINTING SIGNS

In another line of evidence from NSL, we follow a single, humble gesture – the point – as it transforms into a linguistic element. This basic gesture often accompanies speech to indicate real-world locations and objects that surround a speaker. As NSL is transmitted from one cohort to the next, we see an increase in the use of pointing to identify the participants in events, rather than locations or real-world objects (Coppola & Senghas, 2010; Senghas &

Coppola, 2011). With this shift, points take on new grammatical functions, including indicating the subject of a verb, and serving as pronouns and possibly determiners, while participating in an emerging spatially based system of coreference between arguments and predicates. Similar to the finding on motion events, these changes represent separating a holistic, analogue representation into fundamental discrete elements, this time in the spatial domain.

For many reasons, pointing gestures are readily available to be co-opted by a sign language. They are frequent among the gestures that accompany speech (Kendon, 2004; Kita & Özyürek, 2003; McNeill, 1992; and many others), in mature sign languages (Sandler & Lillo-Martin, 2006), and in homesign (Coppola, 2002; Fusellier-Souza, 2006; Goldin-Meadow & Mylander, 1984; Morford, 1996). Points generally are made with an extended finger or hand, though you can also point with other parts of the body, such as an elbow or pursed lips (Kegl, 2002; Kita, 2003). Both hearing children (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979) and deaf children (Bellugi & Klima, 1982; Hoffmeister, 1978) start producing points at a very young age, along with their very first utterances.

Researchers have proposed that pointing entered the grammars of many sign languages as a marker of location, and then expanded to take on other linguistic functions (Pfau & Steinbach, 2006). In mature sign languages, points often identify arguments, using spatial coreference to link them with verbs, in this way indicating who does what to whom (Engberg-Pedersen, 1993; McBurney, 2002; Meier, 1990; Padden, 1988; and others). Points can also serve as determiners, combining with nouns to indicate that a referent is a specific one that has been mentioned before, or a generic or new referent (Bahan, Kegl, MacLaughlin, & Neidle, 1995; Zimmer & Patschke, 1990). Points are also used to describe the locations of objects and events (Emmorey, 2002; Padden, 1988; Shepard-Kegl, 1985).

Because the words of sign languages are produced using the same articulators as gesture, it can be difficult to determine whether certain uses are better categorized as gestural rather than linguistic, so this distinction has been the focus of some debate (cf. Goldin-Meadow & Brentari, 2017); some accounts propose that the more analogue, spatial uses of signs should be considered gestural (Liddell, 1995; Liddell & Metzger, 1998). While we set aside the question of such a dichotomy, it is clear that some

of the changes in the use of points in NSL entail an increase in discrete reference, and the incorporation of points into other aspects of the spatial grammar (Coppola & Senghas, 2010, 2017). Of course, just as in the gestures that accompany speech, points in sign languages can direct interlocutors' attention to things in the immediate environment (Liddell, 1996). But when the referent is not in the immediate here-and-now, the use is more abstract. Within each particular sign language, the forms of points have differentiated to correspond to different functions. For example, in American Sign Language (ASL), a point with the index finger indicates the subject or object of a predicate, like *he* or *him*, while an open palm indicates the possessive, like *his*. Sign languages make extensive use of the three-dimensional space in front of the signer, in an integrated grammatical system (Klima & Bellugi, 1979; Meier, 2002; Meir, 1998; Padden, 1988; Supalla, 1982; Frishberg & Gough, 2000; Taub, 2001; and others). Any use of pointing that develops must be compatible with a sign language's other devices.

Some uses of pointing common to sign languages have also been documented in homesigns. Deaf homesigning children in the United States, Taiwan, Nicaragua, and Spain all use points to refer to locations and objects (Goldin-Meadow, 2003). Two elderly Japanese sisters who are homesigners were also found to use points for these functions, and to indicate non-present persons and objects. They also used points as prosodic markers (Torigoe, 2000). Research with four adult homesigners in Nicaragua found that each used a variety of types of pointing to indicate locations and non-present persons, including marking the agents of an event (Coppola & So, 2005).

To follow the changing use of pointing in early NSL, we systematically compared the points in signed narratives produced by deaf Nicaraguans situated at four different moments along the continuum of language emergence: adult homesigners that never acquired a conventional sign language, and first-, second-, and third-cohort NSL signers. We observed many locative uses of points in the narratives, that is, signs that indicate locations. An example is given in Figure 3.6, in which a first-cohort signer points up and to the right to refer to the location of a bookcase, relative to the perspective of the protagonist in his story. Note that his eye gaze follows the point. This use of eye gaze with a locative point is highly typ-

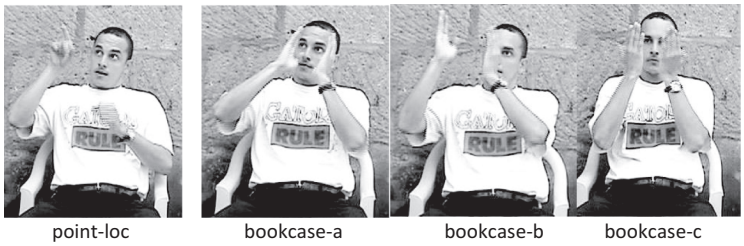

Figure 3.6 An example of a locative point combined with a noun, produced by a first-cohort signer. He produces a point to the upper right, followed by a three-part sign for BOOKCASE, meaning, "There is a bookcase up off to the right side." Note that his eye gaze follows the point (from Senghas & Coppola, 2011).

ical for all four groups, and may even be obligatory. We also found several nominal uses of points, that is, signs that indicate a referent, such as a person or object. An example is shown in Figure 3.7, in which a third-cohort signer points left to refer to the protagonist of her story, Sylvester the Cat, who had been previously associated with the left side of the signing space. Note that this point does not make reference to the location of the cat in the story; rather, it indexes the cat as the agent of an event. The nominal points are quite different in appearance from the locative points. They are articulated more quickly, and with a reduced movement or no movement at all. Eye gaze, in these cases, does not follow the point; you can see in this example that the signer keeps her eyes looking forward, neutrally. Of course, both locative and nominal points entail a displacement of the referent from the real world and real objects. This kind of displacement is

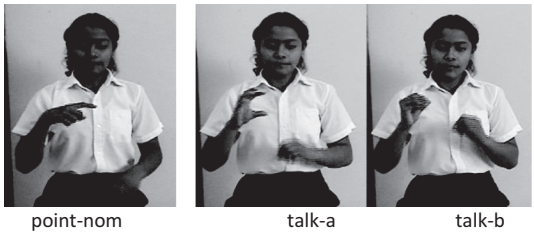

Figure 3.7 An example of a nominal point combined with a verb, produced by a third-cohort signer. She produces a point to her left, followed by the sign TALK, meaning, "He (Sylvester the Cat) talks." Note that the pointing movement is constrained within the signing space, and that her eye gaze does not follow the point (from Senghas & Coppola, 2011).

a fundamental symbolic characteristic of language; it gives us the power to refer to locations and entities that are not part of the here-and-now (Hockett, 1966).

The most striking difference between the locative and nominal points is their pattern of frequency, depending on language group. As can be seen in Figure 3.8, locative points appear frequently in the narratives of all of the groups at a relatively constant rate. A linear regression analysis detected no difference across the groups. Nominal points display a different pattern: they were infrequent in the signing of homesigners and first-cohort signers, more frequent in the signing of the second cohort, and by the third cohort were even more frequent than locative points. Across the groups, each group uses nominal pointing more than the last. A linear regression analysis revealed a significant increase across groups ($F(1,14) = 10.2$, $p = 0.006$).

As the two types of points differentiated across cohorts in form and frequency, we also examined whether they differed in their combinatorial use. For each point, we examined the phrasal context in which the point appeared, specifically determining whether they were combined

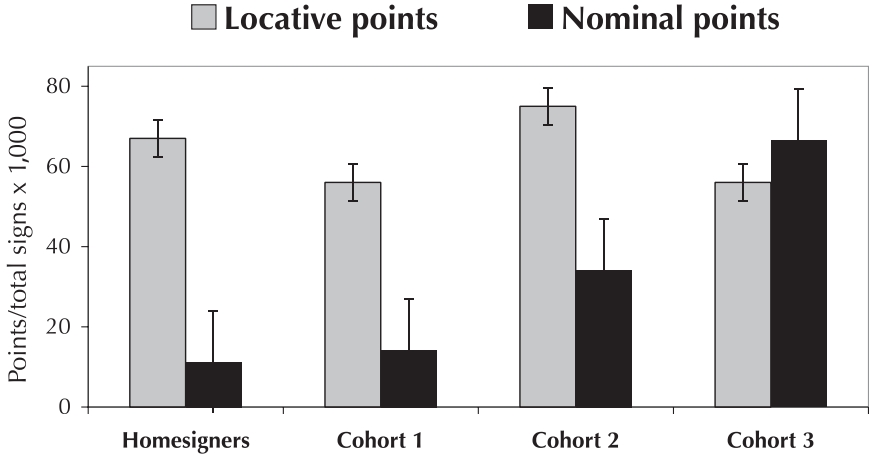

Figure 3.8 Points with locative and nominal uses. In contrast to locative points, which do not differ systematically across groups, nominal points increase across the language continuum, reflecting the emergence of a new function for these forms. (from Senghas & Coppola, 2011).

with a noun, as in POINT + BOOKCASE (Figure 3.6), or a verb, as in POINT + TALK (Figure 3.7). When we considered nominal points combined with verbs, a very clear pattern emerged: the combination increases dramatically across the continuum. A linear regression analysis again revealed a significant increase across the groups: $F(1,14) = 5.9$, $p = 0.03$. No such pattern emerged for nominal points combined with nouns; nor was there such a pattern for combinations of locative points, in combination with either nouns or verbs.

There is apparently a realignment under way that indicates a different structure behind the nominal points with verbs. This corresponds to an emergent function, in which points are increasingly being used in a pronoun-like way to indicate the subjects and objects associated with verbs. For a long time, homesigners and signers have been combining nouns with verbs to form basic sentences. The pattern of change revealed here suggests that this newly differentiated type of point can assume the same position as a noun in the sentence structure. Using the point anaphorically, signers can show who is doing what to whom without repeating nouns or the names of characters.

To summarize, we observe a differentiation in form and function of pointing in NSL, from its origins in homesigns, as it was transmitted down through three sequential cohorts of signers. What started out with a more analogue, locative meaning, close to its gestural roots, has progressively taken on a more discrete, abstract, and displaced function. With these changes, pointing signs have become reduced phonetically, losing most of their movement across space. The new points participate in constructions that give them a more categorical and less context-bound flavor than the co-speech forms that are presumably their origin.

Along with these changes in form and function, points are being integrated into the linguistic system of NSL, becoming part of its emergent three-dimensional spatial grammar. Other work has documented changes in other linguistic domains of NSL, over the same period of transmission, that entail a similar differentiation of the use of the signing space. For example, we have proposed that locative uses of spatial verbs (e.g., describing where people are sitting) produced by early cohorts of NSL signers were a precursor to more abstract, grammatical uses (e.g., indicating that signs are coreferent or co-indexed) produced by

younger, more recent cohorts (Senghas, 2003). What is common to both of these changes is that spatially marked signs lose spatial meaning. In the case of pointing, the locative piece must be separated out from a holistic package that includes the physical, spatial context, leaving a discrete form, and some of its non-spatial semiotic content. Once the point has been segmented in this way, it can be combined with other linguistic elements, including spatial morphology, to form phrases and sentences.

PARALLELS TO GRAMMATICALIZATION PROCESSES

The changes we have observed in NSL resemble certain changes documented in the grammaticalization of spoken languages (Heine, Claudi, & Hünnemeyer, 1991; Hopper, 1991). All languages change as they are passed from one generation to the next. Certain patterns of change are repeatedly observed as components of language take on new forms and functions. In *desemanticization*, or *semantic bleaching*, a lexical item loses meaning as it acquires a grammatical function. In *decategorialization*, a lexical item loses properties characteristic of its category, such as a verb losing the ability to constitute a predicate, and to take arguments. In *erosion*, or *phonetic reduction*, a lexical item loses parts of its pronounced phonetic content. Through these processes, over the history of a language, on a timeline much more extensive than the one studied here, certain individual elements pass through predictable unidirectional changes. Lexical items with rich meanings are created or adopted, take on grammatical functions, shrink, and even disappear, to be replaced at each stage by items behind them in the cycle. There is no one moment when a language is done evolving, and no one stage is more linguistic than any other. We presume that, while following a similar path, the changes we have captured in NSL are accelerated because, at such an early stage of language emergence, there is no previous grammatical material to displace. Like stop-motion photographers presenting a flower as it buds and blooms, we can record as various gestures and lexical signs, which are available early in the process, are taken up and differentiated to link arguments with verbs, indicate subjects, serve as pronouns and possibly determiners, differentiate subjects and objects, and track and switch reference.

When taken up by modern human language learners, even nonlinguistic communicative expressions can serve as the raw materials to build a language. In the case of NSL, we hypothesize that the gestural behavior of hearing Spanish speakers has been reanalyzed by deaf child learners and incrementally reshaped into linguistic systems similar to other sign languages around the world. To the degree that these developments resemble historical changes observed in other, more mature languages, we speculate that the same learning mechanisms underlie both kinds of change. These mechanisms include combining, dividing, and mapping capacities possessed by every learner. Though all three types of mechanism operate at every transition, because they operate on different inputs, the outcome is different at every stage. Ultimately, after multiple iterations of learning, these processes yield a complex combinatorial system that can be acquired easily by any child.

Evidence from children learning mature sign languages suggests similar processes during typical acquisition. Children must discover the basic units in their language by dividing complex constructions at the seams. Morphemes that are typically bound can consequently appear in isolation in child signing. For example, in ASL, complex verbs simultaneously include subject and object information through spatial modulations. In research on the acquisition of ASL verb agreement, Meier (1987) found that children initially produce sequential strings of morphemes rather than combine verb agreement elements into the single, complex movement found in their adult models. Oversegmentation during the acquisition of ASL has been observed across a number of element types, including the agent and patient of a transitive event, and, as in NSL, the manner and path of a motion event (Newport, 1981, 1990). Of course, as young learners continue to be exposed to the complex expressions produced by fluent signers of ASL, they discover its combinatorial structure and converge on the target grammar, leaving their oversegmented expressions behind.

THE ITERATED APPLICATION OF LEARNING PROCESSES

Shared learning mechanisms, common to all human children, can explain the universal characteristics of languages over time and around the world. We need not fall back on a built-in grammar to provide default settings

when learners are presented with incomplete or inconsistent language input. (For an example of such a proposal, see Bickerton (1984, 2014), who posits specific-enough defaults for a single generation of child learners to produce a new grammar in cases of creoles.) Natural human language can be the inevitable product of human language-learning mechanisms without being already fully specified in the learner or in the input. A crucial ingredient in this process is multiple iterations of learning. Simon Kirby and his colleagues (e.g., Kirby et al., 2007; Kirby, Cornish, & Smith, 2008) have demonstrated how multiple iterative passes of learning apply pressure that shapes a system in a predictable way, amplifying any small initial biases and yielding combinatorial structure. I contend that while the iterative process of transmission is necessary for structure to emerge, the nature of the structure that emerges is the product of the nature of the learners. In the case of human language, combinatorial grammars are the product of the specific mapping, combining, and dividing characteristics of human learners.

A similar process can be observed in the acquisition of species-specific song by oscine songbirds. Zebra finch song is produced by males of the species, and acquired by juveniles through live exposure to adult tutors. Male zebra finches raised in a colony without adult males will produce a distorted, atypical song, characterized by long syllables and stuttering, and lacking natural wild-type structure. Féher and her colleagues used such isolate males, and their isolate song, as the model for a new generation of juvenile male learners (Féher, Wang, Saar, Mitra, & Tchernichovski, 2009). The juveniles imitated the isolate tutors, but altered some characteristics of the song. This second generation's newer, altered song was then used as the model for the next generation of learners, and so on. The alterations accumulated with each generation of transmission, resulting in the evolution of wild-type song after only four generations.

This iterative application is necessary, but not sufficient, for evolution to occur. Multiple generational transitions will produce patterned output only to the extent that every learner is applying the same mechanisms and biases. Successive iterations must be comparable. To take an analogous example from physics, consider a metal plate being made to vibrate by a pure tone, a sine wave. Grains of salt scattered on the vibrating plate will begin to redistribute themselves, and after several cycles of redistribution,

settle into a structured resonance pattern, a beautiful array with apparent structure and substructure, like a giant snowflake. However, if the frequency of the vibration were to change randomly every second, the salt would move around, but each change would yield a random shift from its previous state, and the salt would not settle into a regular pattern.

In the same way, changing the species of songbird with every generation would not lead to convergence on a natural oscine song after multiple iterations, even if one started with the same isolate zebra finch song as the seed. A juvenile zebra finch recognizes a good chunk of zebra finch song when it hears it, but a lark will have different preferences, and undo any zebra finch patterning. And, despite their exquisite pattern-finding abilities, successive human learners exposed to the isolate zebra finch song as the seed would not transform it into wild-type song, no matter how many generations were applied – and zebra finches, in turn, would never restructure Nicaraguan motion event gestures into a segmented string of manner and path elements. To create a regular, patterned system, iterative learning depends on equally equipped learners.

A FOSSIL RECORD OF A CRITICAL PERIOD

A striking pattern within the community of signers of NSL, also true of the zebra finch, is that a record of the changes from one generation to the next is preserved in order, even in the present-day systems of adults. Recall that as we compare deaf Nicaraguan 50-year-olds, to 40-year-olds, to 30-year-olds, we find the most developed form of NSL in the younger adults, not in the older adults who have more years of experience with the language. Of course, cultural transmission requires adjacent age cohorts to be in social contact with each other, and the conversations go both ways, but the transmission and change is unidirectional.

This pattern reveals that children and adults have different effects on the language. If adults using NSL were able to shape it as children do, or were as able to learn the changes that others developed, we would find no differences today between adult-age cohorts. Everyone would learn the same, most up-to-date variant through their shared contact at every age. The fact that older signers retain an earlier form suggests that they stopped analyzing and realigning their language system many years ago,

while the next-younger cohort that followed them continued to change. Evidently, the mechanisms necessary for learning and creating language are most active only during an early period in each individual's lifetime.

ARE COMBINING, DIVIDING, AND MAPPING SPECIFIC TO THE LANGUAGE DOMAIN?

Children use grouping, analyzing, and aligning strategies for many kinds of learning. One might suggest that the patterns we have observed in language emergence and change over generations are the natural outcome of human perceptual and memory systems, applied to what happens to be language input. Perhaps this is the only way people can encode or remember incoming streams of information. Of course, we cannot perform beyond our perceptual, cognitive, and memory limitations. Even so, language appears to be subject to a special treatment, not imposed on everyday, nonlinguistic input. Even everyday gestures are not broken down the same way language information is. For example, the hand movements produced by Spanish speakers describing motion events show that children must be able to learn holistic gestures, like a *rolling-down* movement, and map it to entire events, entailing no segmentation or combination of elements. Such gestural productions evidently get passed down and relearned from generation to generation, and emerge unscathed. It was only when deaf children treated such input as if it were language that such gestures were reanalyzed into separate elements representing manner and path. Similarly, children who observe gestures that pantomime actions like *giving* will mature into adults who perform similar mimetic gestures. They don't force the gestures to separate into segments indicating an agent, an action, and a patient the way deaf children learning ASL do. Children treat nonlinguistic gestures and behavior differently from language. They don't subject it to the same kind of analysis.

By the same token, humans are able to master highly structured nonlinguistic systems. For example, we can learn to use symbolic analogue systems like diagrams and maps. We can learn competitive sports and dance moves. The fact that such cultural content exists shows that nonlinguistic systems can be created, passed on, and built up over generations

without being made language-like in the process. We clearly are not compelled to apply the same mechanisms to all system learning, or even to all symbolic communication.

Children's approach to language acquisition is more than a general impulse to analyze and recombine; children have intuitions about precisely how to carry out these processes to achieve alignment between representations as they are learning the language. The ecology of the language, as it develops in the child, will influence the patterns the child can later discover. Regularities in one domain can bleed over into another domain, having cascading effects. Returning to our example about trochaic and iambic biases, it appears that the trochaic bias emerges spontaneously, independent of experience, while the iambic bias must be learned from exposure. This bias of grouping could be used to reveal syntactic properties, such as whether a language is head-initial or head-final (Toro, 2016). The challenge in language acquisition research lies in discovering such specifics. Which aspects of languages are the necessary outcomes of acquisition mechanisms, and what are the (merely) compatible features that emerged slowly over millennia of cultural evolution? What is it that can be encoded in language, and what kinds of mappings motivate children's analyses? Do all languages construe motion events as a combination of a manner and a path? Do all languages construe action events as entailing agents? The study of emerging languages, in conjunction with typical acquisition and historical language change, can help us pinpoint which kinds of changes represent a random walk from the input, and which have children as their guide.

The fundamental processes of combining, dividing, and mapping across representations are present in every child from the moment language acquisition begins. With each generation, these processes build and reshape all of the living languages of the earth. They give languages their embedded hierarchical structure, their referential capacity, and their effortless learnability. Mature natural human languages have been subject to learning so many times that we cannot perceive the effect of another pass. But through a community of children, with a desire to communicate, these fundamental processes have transformed non-language into new language within a few short generations.

REFERENCES

Bahan, B., Kegl, J., MacLaughlin, D., & Neidle, C. (1995). Convergent evidence for the structure of determiner phrases in American Sign Language. In L. Gabriele, D. Hardison, & R. Westmoreland (Eds.), *FLSM VI: Proceedings of the Sixth Annual Meeting of the Formal Linguistics Society of Mid-America. Volume Two: Syntax II & Semantics/Pragmatics* (pp. 1–12). Bloomington, IN: Indiana University Linguistics Club.

Bates, E., Benigni, L., Bretherton, I., Camaioni, L., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.

Bellugi, U., & Klima, E. (1982). From gesture to sign: Deixis in a visuo-gestural language. In R. J. Jarvella & W. Klein (Eds.), *Speech, place, and action: Studies in deixis and related topics* (pp. 279–313). New York: Wiley.

Bickerton, D. (1984). The language bioprogram hypothesis. *Behavioral and Brian Sciences*, *7*, 173–221.

Bickerton, D. (2014). *More than nature needs: Language, mind, and evolution*. Cambridge, MA: Harvard University Press.

Bolton, T. (1894). Rhythm. *The American Journal of Psychology*, 6, 145–238.

Christiansen, M., & Chater, N. (2008). Language as shaped by the brain. *Behavioral and Brain Sciences*, *31*, 489–558.

Coppola, M. (2002). *The emergence of the grammatical category of subject in home sign: Evidence from family-based gesture systems in Nicaragua.* (Unpublished doctoral dissertation.) Brain and Cognitive Sciences, University of Rochester, Rochester, NY.

Coppola, M., & Newport, E. L. (2005). Grammatical subjects in home sign: Abstract linguistic structure in adult primary gesture systems without linguistic input. *Proceedings of the National Academy of Sciences*, *102*, 19249–19253.

Coppola, M., & Senghas, A. (2010). Deixis in an emerging sign language. In D. Brentari (Ed.), *Sign languages: A Cambridge language survey* (pp. 543–569). Cambridge: Cambridge University Press.

Coppola, M., & Senghas, A. (2017). Is it language (yet)? The allure of the gesture/language binary. Commentary on S. Goldin-Meadow & D. Brentari, Gesture, sign and language: The coming of age of sign language and gesture studies. *Behavioral & Brain Sciences*, *40*, 21–23.

Coppola, M., & So, W. C. (2005). Abstract and object-anchored deixis: Pointing and spatial layout in adult homesign systems in Nicaragua. In M. R. Clark-Cotton, A. Brugos, & S. Ha (Eds.), *BUCLD 29: Proceedings of the 30th Annual Boston University Conference on Language Development* (pp. 144–155). Somerville, MA: Cascadilla.

Deacon, T. W. (1997). *The symbolic species: The co-evolution of language and the brain*. New York: Norton.

Emmorey, K. (2002). *Language, cognition, and the brain: Insights from sign language research*. Mahwah, NJ: Lawrence Erlbaum Associates.

Engberg-Pedersen, E. (1993). *Space in Danish Sign Language: The semantics and morphosyntax of the use of space in a visual language*. Hamburg: Signum Press.

Féher, O., Wang, H., Saar, S., Mitra, P. P., & Tchernichovski, O. (2009). De novo establishment of wild-type song culture in the zebra finch. *Nature*, *459*(7246), 564–568.

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

Fisher, C. (1994). Structure and meaning in the verb lexicon: Input for a syntax-aided verb learning procedure. *Language and Cognitive Processes*, *9*, 473–517.

Fisher, C., Hall, G., Rakowitz, S., & Gleitman, L. (1994). When it is better to receive than to give: Structural and cognitive factors in acquiring a first vocabulary. *Lingua*, *92*, 333–376.

Frishberg, N., & Gough, B. (2000). Morphology in American Sign Language. *Sign Language and Linguistics*, *3*(1), 103–131.

Fusellier-Souza, I. (2006). Emergence and development of signed languages: From a semiogenetic point of view. *Sign Language Studies*, *7*, 30–56.

Goldin-Meadow, S. (2003). *The resilience of language: What gesture creation in deaf children can tell us about how all children learn language*. New York: Psychology Press.

Goldin-Meadow, S., & Brentari, D. (2017). Gesture, sign, and language: The coming of age of sign language and gesture studies. *Behavioral and Brain Sciences*, *40*, E46.

Goldin-Meadow, S., & Mylander, C. (1984). Gestural communication in deaf children: The effects and noneffects of parental input on early language. *Monographs of the Society for Research on Child Development*, *49*.

Hay, J. F., & Saffran, J. R. (2012). Rhythmic grouping biases constrain infant statistical learning. *Infancy*, *17*, 610–641.

Heine, B., Claudi, U., & Hünnemeyer, F. (Eds.). (1991). *From cognition to grammar: Evidence from African languages. Vol. 1: Approaches to grammaticalization*. Amsterdam: John Benjamins.

Hockett, C. F. (1966). The problem of universals in language. In J. H. Greenberg (Ed.), *Universals of language* (pp. 1–29). Cambridge, MA: MIT Press.

Hoffmeister, R. J. (1978). *The development of demonstrative pronouns, locatives, and personal pronouns in the acquisition of ASL by deaf children of deaf parents*. (Unpublished doctoral dissertation.) University of Minnesota.

Hopper, P. J. (1991). On some principles of grammaticization. In E. C. Traugott & B. Heine (Eds.), *Approaches to grammaticalization* (pp. 17–35). Amsterdam: John Benjamins.

Hurford, J. R. (2012). *Language in the light of evolution: Volume II, the origins of grammar*. Oxford: Oxford University Press.

Kegl, J. (2002). Language emergence in a language-ready brain. Acquisition. In G. Morgan & B. Woll (Eds.), *Directions in sign language acquisition* (pp. 207–254). Amsterdam: Benjamins.

Kegl, J., & Iwata, G. (1989). Lenguaje de Signos Nicaragüense: A pidgin sheds light on the "creole?" ASL. In R. Carlson, S. DeLancey, S. Gilden, D. Payne, & A. Saxena (Eds.), *Fourth Annual Meeting of the Pacific Linguistics Conference* (pp. 266–294). Eugene, Oregon.

Keller, R. (1995). *On language change: The invisible hand in language*. New York: Routledge.

Kendon, A. (2004). *Gesture: Visible action as utterance*. Cambridge: Cambridge University Press.

Kirby, S., Cornish, H., & Smith, K. (2008). Cumulative cultural evolution in the laboratory: An experimental approach to the origins of structure in human language. *Proceedings of the National Academy of Sciences*, *105*, 10681–10686.

Kirby, S., Dowman, M., & Griffiths, T. L. (2007). Innateness and culture in the evolution of language. *Proceedings of the National Academy of Sciences*, *104*(12), 5241–5245.

Kita, S. (2003). Pointing: A foundational building block of human communication. In S. Kita (Ed.), *Pointing: Where language, culture, and cognition meet* (pp. 1–8). Mahwah, NJ: Erlbaum.

Kita, S., & Özyürek, A. (2003). What does cross-linguistic variation in semantic coordination of speech and gesture reveal?: Evidence for an interface representation of spatial thinking and speaking. *Journal of Memory and Language*, *48*, 16–32.

Klima, E., & Bellugi, U. (1979). *The signs of language*. Cambridge, MA: Harvard University Press.

Liddell, S. K. (1995). Real, surrogate, and token space: Grammatical consequences in ASL. In K. Emmorey & J. S. Reilly (Eds.), *Language, gesture, and space* (pp. 19–41). Hillsdale, NJ: Erlbaum.

Liddell, S. K. (1996). Spatial representations in discourse: Comparing spoken and signed language. *Lingua*, *98*, 145–167.

Liddell, S. K., & Metzger, M. (1998). Gesture in sign language discourse. *Journal of Pragmatics*, *30*, 657–697.

McBurney, S. L. (2002). Pronominal reference in signed and spoken language. In R. P. Meier, K. Cormier, & D. Quinto-Pozos (Eds.), *Modality and structure in signed and spoken languages (pp. 329–369)*. Cambridge, UK: Cambridge University Press.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought*. Chicago, IL: University of Chicago Press.

Meier, R. P. (1987). Elicited imitation of verb agreement in American Sign Language: Iconically or morphologically determined? *Journal of Memory and Language*, *26*, 362–376.

Meier, R. P. (1990). Person deixis in American Sign Language. In S. Fischer & P. Siple (Eds.), *Theoretical issues in sign language research* (pp. 175–190). Chicago, IL: University of Chicago Press.

Meier, R. P. (2002). The acquisition of verb agreement: Pointing out arguments for the linguistic status of agreement in sign languages. In G. Morgan & B. Woll (Eds.), *Current developments in the study of signed language acquisition* (pp. 115–141). Amsterdam: John Benjamins.

Meir, I. (1998). Syntactic-semantic interaction in Israeli sign language verbs: The case of backwards verbs. *Sign Language & Linguistics*, *1*, 3–37.

Morford, J. P. (1996). Insights to language from the study of gesture: A review of research on the gestural communication of non-signing deaf people. *Language and Communication*, *16*, 165–178.

Morgan, J. L. (1996). A rhythmic bias in preverbal speech segmentation. *Journal of Memory and Language*, *35*, 666–688.

Nespor, M., Shukla, M., van de Vijver, R., Avesani, C., Schraudolf, H., & Donati, C. (2008). Different phrasal prominence realizations in VO and OV languages. *Lingue E Linguaggio*, *2*, 1–29.

Newport, E. L. (1981). Constraints on structure: Evidence from American Sign Language and language learning. In W. A. Collins (Ed.), *Aspects of the development of competence. Minnesota Symposium on Child Psychology, Vol. 14* (pp. 93–124). Hillsdale, NJ: Lawrence Erlbaum Associates.

Newport, E. L. (1990). Maturational constraints on language learning. *Cognitive Science*, *14*, 11.

Padden, C. (1988). *Interaction of morphology and syntax in American Sign Language*. New York: Garland Press.

Pfau, R., & Steinbach, M. (Eds.). (2006). *Modality-independent and modality-specific aspects of grammaticalization in sign languages. Vol. 24: Linguistics in Potsdam*. Potsdam, Germany: Institute of Linguistics.

Pinker, S., & Bloom, P. (1990). Natural language and natural selection. *Behavioral and Brain Sciences*, *13*(4), 707–727.

Polich, L. (2005). *The emergence of the deaf community in Nicaragua: "With Sign Language You Can Learn So Much"*. Washington, DC: Gallaudet University Press.

Sandler, W., & Lillo-Martin, D. C. (2006). *Sign language and linguistic universals*. Cambridge, UK: Cambridge University Press.

Senghas, A. (1995). *Children's contribution to the birth of Nicaraguan Sign Language*. (Unpublished doctoral dissertation.) Brain and Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA.

Senghas, A. (2003). Intergenerational influence and ontogenetic development in the emergence of spatial grammar in Nicaraguan Sign Language. *Cognitive Development*, *18*, 511–531.

Senghas, A., & Coppola, M. (2001). Children creating language: How Nicaraguan Sign Language acquired a spatial grammar. *Psychological Science*, *12*(4), 323–328.

Senghas, A., & Coppola, M. (2011). Getting to the point: How a simple gesture became a linguistic element in Nicaraguan signing. In D. J. Napoli & G. Mathur (Eds.), *Deaf around the world: The impact of language* (pp. 127–143). New York: Oxford University Press.

Senghas, A., Kita, S., & Özyürek, A. (2004). Children creating core properties of language: Evidence from an emerging sign language in Nicaragua. *Science*, *305*(5691), 1779–1782.

Senghas, A., & Littman, S. (2004, September). *Segmentation in the expression of motion events in co-speech gesture, Nicaraguan Sign Language (NSL), and Spanish Sign Language (LSE)* [Paper presentation]. Eighth International Conference on Theoretical Issues in Sign Language Research (TISLR8), Barcelona, Spain.

Senghas, A., Özyürek, Ä., & Goldin-Meadow, S. (2013). Homesign as a way-station between co-speech gesture and sign language: The evolution of segmentation and sequencing. In R. Botha & M. Everaert (Eds.), *The evolutionary origins of language; studies on the evolution of language* (pp. 62–76). Oxford: Oxford University Press.

Senghas, R. J. (1997). *An "unspeakable, unwriteable" language: Deaf identity, language and personhood among the first cohorts of Nicaraguan signers*. (Unpublished doctoral dissertation.) Anthropology, University of Rochester, Rochester, NY.

Shepard-Kegl, J. (1985). *Locative relations in ASL word formation, syntax, and discourse*. (Unpublished doctoral dissertation.) Linguistics, Massachusetts Institute of Technology, Cambridge, MA.

Supalla, T. (1982). *Structure and acquisition of verbs of motion and location in American Sign Language*. (Unpublished doctoral dissertation.) University of California, San Diego, CA.

Talmy, L. (1985). Lexicalization patterns: Semantic structure in lexical forms. In T. Shopen (Ed.), *Language typology and syntactic description* (pp. 36–149). Cambridge: Cambridge University Press.

Taub, S. (2001). *Language from the body: Iconicity and metaphor in American Sign Language*. Cambridge, UK: Cambridge University Press.

Tomasello, M. (1999). The human adaptation for culture. *Annual Review of Anthropology*, *28*, 509–529.

Tomasello, M. (2003). On the different origins of symbols and grammar. In M. Christiansen & S. Kirby (Eds.), *Language evolution* (pp. 94–110). Oxford: Oxford University Press.

Torigoe, T. (2000). *Grammaticalization of pointings and oral movements in a home sign* [Paper Presentation]. Theoretical Issues in Sign Language Research, Amsterdam.

Toro, J. M. (2016). Something old, something new: Combining mechanisms during language acquisition. *Current Directions in Psychological Science*, *25*(2), 130–134.

Zimmer, J., & Patschke, C. G. (1990). A class of determiners in ASL. In C. Lucas (Ed.), *Sign language research: Theoretical issues* (pp. 201–210). Washington, DC: Gallaudet University Press.