4

Language and the manual modality

The communicative resilience of the human species

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All known cultures whose members are hearing exploit the oral modality – the mouth and ear – for language. But the manual modality – the hand and eye – also has a role to play in language, in two very different ways. First, individuals who use the oral modality for language move their hands when they talk – they gesture – and these co-speech gestures form part of the conversation. Second, individuals whose hearing losses prevent them from using the oral modality for language use their hands to communicate – they invent sign languages – and these languages serve all of the functions served by spoken languages. My goal in this chapter is to describe what happens to the manual modality under two distinct circumstances: (1) when it accompanies speech, and thus forms part of language; and (2) when it is used instead of speech as the primary modality for communication, and thus is itself language.

4.1 When the manual modality is used along with speech: Co-speech gesture

4.1.1 The robustness of co-speech gesture

In all cultures that have been examined thus far, speakers have been found to gesture when they talk, even very young speakers. In fact, before children use meaningful words, their meaningless vocalizations, particularly those that are syllabic and therefore speech-like in form, are more likely to be coordinated with manual movements than with other limb movements (Iverson and Fagan, 2004). When children then begin to produce meaningful words, they immediately combine those words with gestures and the combinations are temporally synchronized (i.e., the vocalization occurs on the stroke of the gesture or at its peak, the farthest extension before the hand begins to retract, Butcher and Goldin-Meadow, 2000).

Even more striking, individuals who are blind from birth, and thus have never seen anyone gesture, move their hands when they talk. Moreover, these blind speakers gesture even when talking to blind listeners, and their gestures resemble the gestures that sighted speakers produce when they talk (Iverson and Goldin-Meadow, 1998). Another compelling example of gesture's close tie to speech comes from IW (Cole, 1991). IW suffered an illness at age 19 that affected the nerves of his spinal cord and resulted in loss of the sense of touch and proprioception below the neck, as well as loss of all motor control that depends on proprioceptive feedback. Over time and with great effort, IW learned to control his arm and leg movements using visual attention, and can now exercise control over his posture and movement *if* he can see his limbs – in the dark, he cannot move. Interestingly, however, IW is able to move his unseen hands when he talks – that is, he can gesture, even though he is unable to move his unseen hands voluntarily, for example, when asked to pick up a block (Gallagher *et al.*, 2001).

Gesturing is thus clearly not just hand waving – it's an inseparable part of the act of talking. Although traditionally linguists have not considered gesture to be integral to language, the fact that it is a robust part of the speech act suggests that we need to understand the role gesture plays in our conversations. We turn next to the form co-speech gesture assumes and then explore its functions.

4.1.2 The form of co-speech gesture

Nonverbal behavior, including gesture, has traditionally been assumed to reflect a speaker's feelings or emotions (Wundt, 1973 [1900]; see review in Feyereisen and de Lannoy, 1991). More recently, however, researchers have argued that the gestures speakers produce while talking can convey substantive information about the speaker's thoughts (Kendon, 1980; McNeill, 1992). For example, McNeill (1992) has found that speakers use hand gestures to portray concrete images (such as the actions or attributes of cartoon characters), as well as abstract mathematical concepts (such as quotients, factors, or limits in calculus). Indeed, speakers can even use their hands to convey the complex hierarchical structures found in kinship relations (e.g., to explain why the marriage between two individuals is permitted, or forbidden, within their system of kinship relations, Enfield, 2005).

But gesture and speech convey meaning differently. Speech segments and linearizes meaning. A thought that is likely to be instantaneous is divided up and strung out through time. A single event, say, somebody running across a field, must be conveyed in segments: the runner, the field, the running movement, the direction, and so forth. These segments are organized into a hierarchically structured string of words. The total effect is to present what had been a single instantaneous picture in the form of a hierarchically organized string of segments. Segmentation and linearization are essential characteristics of all linguistic systems (even sign languages, see section 4.2.1).

In contrast, the gestures that accompany speech can present meaning without undergoing segmentation or linearization. Unlike spoken sentences in which lower constituents combine to form higher constituents, each gesture is a complete expression of meaning unto itself (McNeill, 1992). For example, in describing an individual running, a speaker might move his hand forward while wiggling his index and middle fingers. The gesture is a symbol whose parts are meaningful in the context of the whole. The wiggling fingers mean "running" only because we know that the gesture, as a whole, depicts someone running and not because this speaker consistently uses wiggling fingers to mean running. Indeed, in other gestures produced by this same speaker, wiggling fingers may well have a very different meaning (e.g., "indecision between two alternatives"). In order to argue that the gesture for running is composed of separately meaningful parts, one would have to show that the components that comprise the gesture are each used for a stable meaning across the speaker's gestural repertoire (e.g., that the V handshape consistently represents a person, the wiggling fingers consistently represent manner, and the forward motion consistently represents path). The data suggest that there is no such stability in co-speech gesture (McNeill, 1992; Goldin-Meadow *et al.*, 1995).

In addition to the fact that co-speech gestures do not appear to be composed of meaningful parts and thus are not wholes created from parts, these gestures also do not themselves combine to create larger wholes. Most of the time, gestures are "one to a clause," that is, a spoken clause is accompanied by a single gesture (McNeill, 1992). Moreover, even when more than one gesture occurs within a single clause, those gestures do not form a more complex gesture "clause." Each gesture depicts the content from a different angle, bringing out a different aspect or temporal phase, and each is a complete expression of meaning by itself. For example, while uttering the clause, "and she grabs the knife," a speaker produced two gestures: The hand first groped in a circle with the palm facing down and the finger extended (produced as the word "she" was uttered) and then the hand turned up and closed to a fist as though gripping a knife (produced along with the words "grabs the knife"). The gestures are related but do not combine into a single higher unit characterized by the same properties as a spoken clause. Rather, the gestures present successive snapshots of the scene. The spoken words also describe this scene, but whereas the words – "she," "grabs," and "the knife" – combine to form the clause, the gestures – groping and grabbing – do not combine to form anything resembling a clause. Rather, each gesture represents a predicate unto itself (McNeill 1992).

Co-speech gesture is thus not structured like a conventional linguistic system. It has its own representational properties, which work together with speech to form an integrated system. For example, co-speech gestures typically rely on the words they accompany for their interpretation. The same gesture – a twirling motion in the air – can refer to a dancer performing a pirouette when accompanied by the sentence, “she’s a lovely dancer,” but to a person’s lack of progress when accompanied by the sentence, “he seems to be going nowhere.” Even the form of co-speech gesture seems to be influenced by the structural properties of the language it accompanies. For example, English expresses manner and path within the same clause, whereas Turkish expresses the two in separate clauses. The gestures that accompany manner and path constructions in these two languages display a parallel structure – English speakers produce a single gesture combining manner and path (a rolling movement produced while moving the hand forward), whereas Turkish speakers produce two separate gestures (a rolling movement produced in place, followed by a moving forward movement) (Kita and Özyürek, 2003; Kita *et al.*, 2007).

4.1.3 The functions of co-speech gesture

4.1.3.1 The communicative functions co-speech gestures serve

As described earlier, co-speech gesture is not meaningless hand waving but can convey substantive information. Moreover, the information gesture conveys can be quite different from the information conveyed in the speech it accompanies. For example, consider a child asked to participate in a Piagetian conservation task. The child is shown two rows that have the same number of checkers in them. The checkers in one row are then spread out, and the child is asked whether the rows still have the same number of checkers. The child says, “they’re different because you moved them,” indicating that she is a non-conserver. However, her gestures suggest that she does have some insight into conservation – she moves her index finger between the checkers in the two rows, aligning the first checker in row 1 with the first checker in row 2, and so on. Her gestures suggest that she is beginning to understand one-to-one correspondence and, in fact, a child who produces gesture–speech “mismatches” of this sort is particularly likely to profit from instruction in conservation, more likely than a child who does not produce mismatches on this task prior to instruction (Church and Goldin-Meadow, 1986; see also Perry *et al.*, 1988; Alibali and Goldin-Meadow, 1993; Pine *et al.*, 2004). Gesture can thus provide a second, important window onto a speaker’s thoughts.

Not only can researchers armed with video cameras and slow-motion devices glean information from a speaker’s gestures, but ordinary listeners are also sensitive to information conveyed in gesture, both adults (e.g., Graham and Argyle, 1975; Cook and Tanenhaus, 2009) and children (McNeil *et al.*, 2000). Listeners are faster to identify a speaker’s referent when speech is accompanied by gesture than when it is not (Silverman *et al.*, 2010). Listeners are also *more* likely to glean information conveyed in a speaker's words if those words are accompanied by matching gesture than by no gesture (Graham and Argyle, 1975; Thompson and Massaro, 1994; Goldin-Meadow and Sandhofer, 1999; McNeil *et al.*, 2000; Beattie and Shovelton, 2002). Conversely, listeners are *less* likely to glean information conveyed in a speaker's words if the words are accompanied by mismatching gesture than by no gesture (Kelly and Church, 1998; Goldin-Meadow and Sandhofer, 1999; McNeil *et al.*, 2000; see Kelly *et al.*, 2004, Wu and Coulson, 2007, and Özyürek *et al.*, 2007, for evidence from event-related potentials [ERPs] that gesture plays a role in how speech is understood). Moreover, in addition to influencing the information that listeners glean from speech, gesture also conveys its own information that listeners understand. For example, a listener is more likely to attribute one-to-one correspondence to a child who expresses that rationale uniquely in gesture (i.e., not in speech) than to a child who does not express the rationale in either gesture or speech (Goldin-Meadow *et al.*, 1992; see also Alibali *et al.*, 1997).

Listeners are thus able to glean information from a speaker's gestures, and they act on this information – they change how they react to a speaker as a function of the gestures that the speaker produces. For example, when providing instruction on mathematical equivalence problems (e.g., 4+3+6=__+6), teachers offer different problem-solving strategies to children who produce gesture–speech mismatches when they explain how they solved the problems than to children who do not produce gesture–speech mismatches. In particular, teachers provide more different types of problem-solving strategies, and more of their own gesture–speech mismatches, to mismatching children than to matching children (Goldin-Meadow and Singer, 2003). The teachers' mismatches were different from the children's in that both strategies (the one produced in speech and the one produced in gesture) were correct; in contrast, in the child mismatches, at least one strategy (and often two) was incorrect. Teachers thus vary the instruction they give children in response to the children's gestures. And those gestures make a difference. In an experimental study designed to determine whether the instruction teachers spontaneously gave mismatching children was good for learning, Singer and Goldin-Meadow (2005) found that providing children with two different strategies, one in speech and another in gesture (i.e., a mismatch), was particularly effective in teaching them how to solve the mathematical equivalence problems, more effective than providing the same two strategies entirely in speech. Gesture is thus part of the conversation and, as such, can be harnessed in the classroom and other situations (e.g., an interview, Broaders and Goldin-Meadow, 2010) to bring about change.

4.1.3.2 The cognitive functions co-speech gestures serve

Gesture affects not only listeners but also the speakers themselves, and does so in a variety of ways. First, gesturing may help speakers find their words, that is, to access lexical items that feel as though they are on the "tip of the tongue" (Rauscher *et al.*, 1996). Speakers are, in fact, more likely to gesture when they are saying something new (Chawla and Krauss, 1994), when they are saying something unpredictable (Beattie and Shovelton, 2000), and when word-finding is made more difficult (Rauscher *et al.*, 1996). In addition, brain-damaged patients with difficulties in finding words (i.e., patients with aphasia) gesture at a higher rate than patients with visuo-spatial difficulties (Hadar *et al.*, 1998). Gesturing is thus associated with having difficulties in lexical access. More convincing still is the fact that speakers are more successful at resolving a tip-of-the-tongue word-finding state when they are permitted to gesture than when they are not permitted to gesture, for both adult (Frick-Horbury and Guttentag, 1998) and child (Pine *et al.*, 2007) speakers (but see Beattie and Coughlan, 1999, for a different view).

Second, gesturing may help link the words the speaker produces to the world. Deictic gestures, in particular, may help the speaker make use of the surrounding space (Ballard *et al.*, 1997). For example, gesturing seems to be important in coordinating number words with objects for children learning to count, and also in keeping track of which objects have already been counted (Saxe and Kaplan, 1981). Children make fewer errors coordinating number words and objects when they gesture while counting than when they watch a puppet gesture while they count, or than when they are told not to gesture while counting (Alibali and DiRusso, 1999). However, a speaker's gestures do not have to be directed at visible objects in order for that speaker to benefit from gesturing (Ping and Goldin-Meadow, 2010), suggesting that gesturing need not be tied to the physical environment in order to be effective.

Third, gesturing can reduce demands on thinking and remembering. Speakers gesture more on conceptually difficult problems, even when the lexical demands of the problem are equivalent (Alibali *et al.*, 2000; Hostetter and Alibali, 2007; Melinger and Kita, 2007; Kita and Davies, 2009). For example, when adult speakers are asked to describe dot patterns, they gesture more when talking about patterns that are more difficult to conceptualize (i.e., patterns that do not have lines connecting the dots) than about patterns that are easier to conceptualize (i.e., patterns that do have lines, Hostetter and Alibali, 2007). As a second example, children gesture more when they are asked to solve problems that require conceptualization (e.g., Piagetian conservation problems) than when they are asked to describe a scene (e.g., to describe the materials used in a conservation problem, Alibali *et al.*, 2000). Since gesture is a natural format for capturing spatial information, it is not surprising that it is particularly effective in reducing conceptual demands in visuospatial tasks. Gesturing has been shown to maintain visuospatial information in memory (Wesp *et al.*, 2001; Morsella and Krauss, 2005), facilitate packaging of visuospatial information for spoken language (Kita, 2000), and facilitate transformation of spatial information in memory (when performing mental rotation tasks, adults are particularly successful if they produce gestures consistent with the actual rotation that is to be performed, Wexler *et al.*, 1998; Wohlschläger and Wohlschläger, 1998; Schwartz and Black, 1999). Although consistent with the idea that gesturing reduces demands on conceptualization, all of these studies manipulate problem difficulty and observe the effects of the manipulation on gesturing. But to definitively demonstrate that gesturing plays a role in reducing conceptualization demands (as opposed to merely reflecting those demands), we need to manipulate gesture and then find that the manipulation reduces demands on conceptualization.

This type of gesture manipulation has been done with respect to working memory. Goldin-Meadow *et al.* (2001) asked speakers to remember an unrelated list of items while explaining how they solved a math problem. Half of the speakers were permitted to gesture during their explanations, and half were prevented from gesturing. Speakers (both adults and children) were able to maintain more items in verbal working memory, and thus recall more items, when they gestured during their explanations than when they did not gesture. This effect held even for problems on which the speakers chose not to gesture (as opposed to being told not to gesture), thus making it clear that the effect was not due to being instructed not to gesture (see also Wagner *et al.*, 2004). Gesturing reduces demand on working memory even when the gestures are not directed at visually present objects (Ping and Goldin-Meadow, 2010), suggesting that gesturing confers its benefits by more than simply tying abstract speech to objects directly visible in the environment. Importantly, it is not just moving the hands that reduces demand on working memory – it is the fact that the moving hands are meaningful. Speakers remember more when asked to gesture during their explanations than when asked to produce meaningless rhythmic movements or no movements at all during their explanations (Cook *et al.*, 2010).

Finally, gesturing can affect speakers by activating old thoughts or forming new ones. Broaders *et al.* (2007) asked children to explain how they solved six mathematical equivalence problems with no instructions about what to do with their hands. They then asked the children to solve a second set of comparable problems and divided the children into three groups: some were told to move their hands as they explained their solutions to this second set of problems; some were told not to move their hands; and some were given no instructions about their hands. Children who were told to gesture on the second set of problems added strategies to their repertoires that they had not previously produced; children who were told not to gesture, and children given no instructions at all, did not. Most of the added strategies were produced in gesture and not in speech and, surprisingly, most were correct. In addition, when later given instruction in mathematical equivalence, it was the children who had been told to gesture, and had added strategies to their repertoires, who profited from the instruction and learned how to solve the math problems.

Being told to gesture thus encouraged children to express ideas that they had previously not expressed, which, in turn, led to learning.

To determine whether gesture can create new ideas, we need to teach speakers to move their hands in particular ways. If speakers can extract meaning from their hand movements, they should be sensitive to the particular movements they are taught to produce and learn accordingly. Alternatively, all that may matter is that speakers move their hands. If so, they should learn regardless of which movements they produce. To investigate these alternatives, Goldin-Meadow *et al.* (2009) manipulated gesturing during a math lesson. They found that children required to produce *correct* gestures instantiating the *grouping* strategy learned more than children required to produce *partially correct* gestures, who learned more than children required to produce *no* gestures. Moreover, after the lesson, the children who improved began producing the *grouping* strategy in speech. Note that, during training, the children produced *grouping* only in gesture (and not in speech) and the teacher did not produce it in either modality. Gesturing thus plays a role not only in processing old ideas, but also in creating new ones.

To summarize thus far, when speakers talk, they move their hands and those hand movements form an integrated system with the speech they accompany, at times conveying information that is not found in speech. These gestures have an impact on communication through the listener and an impact on cognition through the speaker. We turn next to the hand movements people produce in the absence of speech, beginning with conventional sign languages created by deaf communities.

4.2 When the manual modality is used instead of speech: Sign language

We have seen that the manual modality assumes an imagistic form when it is used in conjunction with a segmented and combinatorial system (i.e., speech). But what happens when the manual modality must fulfill all of the functions of language on its own? Under these circumstances, the manual modality changes its form and itself becomes segmented and combinatorial. We see these form changes not only in established sign languages that have been handed down from generation to generation within a deaf community, but also in newly emerging sign languages.

4.2.1 Established sign languages

Sign languages of the deaf are autonomous languages, independent of the spoken languages of hearing cultures. The most striking example of this independence is that American Sign Language (ASL) is structured very differently from British Sign Language (BSL), despite the fact that English is the spoken language used by the hearing communities surrounding both sign languages. Even though sign languages are processed by the hand and eye, rather than the mouth and ear, sign languages have the defining properties of segmentation and combination that characterize all spoken language systems (Klima and Bellugi, 1979; Sandler and Lillo-Martin, 2006). Sign languages are structured at the sentence level (syntactic structure), at the sign level (morphological structure), and at the level of sub-sign, and have meaningless elements akin to phonemes ("phonological" structure). Just like words in spoken languages (but unlike the gestures that accompany speech, Goldin-Meadow *et al.*, 1996), signs combine to create larger wholes (sentences) that are typically characterized by a basic order, for example, SVO (Subject-Verb-Object) in ASL; SOV in Sign Language of the Netherlands. Moreover, the signs that comprise the sentences are themselves composed of meaningful components (morphemes).

Many of the signs in a language like ASL are iconic. However, iconicity is not unique to sign languages and can be found in spoken languages as well (e.g., Shintel and Nusbaum, 2008). Moreover, the iconicity found in a sign language does not appear to play a significant role in the way the language is processed or learned. For example, young children are just as likely to learn a sign whose form does not resemble its referent as a sign whose form is an iconic depiction of the referent (Bonvillian *et al.*, 1983). Similarly, young sign learners find morphologically complex constructions difficult to learn even if they are iconic (e.g., although moving the sign *give* from the chest toward the listener seems to be an iconically transparent way of expressing *I give to you*, the sign is, in fact, morphologically complex as it is marked for both the agent *I* and the recipient *you* and, as such, turns out to be a relatively late acquisition in ASL learners, Meier, 1987).

Moreover, sign languages do not always take advantage of the iconic potential that the manual modality offers. For example, although it would be easy enough to indicate the manner of motion in a sign describing a skate boarder circling around, to be grammatically correct, the ASL signer must produce separate, serially linked signs for the manner and for the path (Supalla, 1990). As another example, the sign for *slow* in ASL is made by moving one hand across the back of the other hand. When the sign is modified to be *very slow*, it is made more rapidly since this is the particular modification of movement associated with an intensification meaning in ASL (Klima and Bellugi, 1979). Thus, modifying the meaning of a sign can reduce its iconicity in a conventional sign language simply because the meaning of the sign as a whole is made up of the meanings of the components that comprise it.

In contrast, as described earlier, the gestures that accompany speech are not composed of parts but are instead non-compositional wholes. Since the gesture as a whole must be a good representation of its referent, the addition of semantic information to a spontaneous gesture always increases its iconicity – if something is thought of as very slow, the gesture for it is also very slow (McNeill, 1992). The gesture *as a whole* represents *very slow* and, although one could, in principle, break up the gesture into two parts (such as *slow*, a movement across the back of the hand, and *very*, an exaggerated and slowed movement), there is no evidence that these particular forms have independent and consistent meaning across a range of gestures – as they would have to if they were part of a combinatorial system in a conventional sign language.

Whether the modality in which sign language is produced shapes how the language is structured is an open (and contested) question. The sign languages that have been studied thus far are, on the whole, morphologically rich and thus comparable to a subset, and not the entire range, of spoken languages (we have not yet discovered, for example, an established sign language that has very little morphology, a characteristic of some spoken languages, e.g., Mandarin Chinese). Sign languages might occupy only a piece of the continuum along which spoken languages are arrayed because of pressures from the manual modality. However, other factors, such as the fact that sign languages tend to be relatively young and to evolve under unusual social circumstances, might also influence the way sign languages are structured.

4.2.2 Emerging sign languages

Spoken languages have long histories and, although we can fruitfully examine how these languages change over time, we cannot go back to their roots. And new spoken languages are not really new. For example, *pidgin* languages arise when speakers of two or more mutually unintelligible languages come into contact and need to communicate; the language becomes a *creole* once children are born into the pidgin-speaking households (McWhorter, 1998; Mufwene, 2001). But pidgins and creoles are grounded in at least two existing spoken languages and, in this sense, are built on previously existing languages. In contrast, languages do arise *de novo* in the manual modality. When deaf people who have not been exposed to a sign language and are unable to learn spoken language come together to form a community, a new sign language is often born. These sign languages are of two types, distinguished by the social conditions under which they emerge (Woll and Ladd, 2003; Sandler, 2005; Meir, Sandler *et al.*, 2010) – *village sign languages*, which emerge when deaf children are born into existing communities, and *deaf community sign languages*, which emerge when deaf individuals are brought together to form a community.

4.2.2.1 A village sign language: Al-Sayyid Bedouin Sign Language

An example of a village sign language is Al-Sayyid Bedouin Sign Language (ABSL, Sandler *et al.*, 2005). A community, now in its seventh generation and containing 3,500 members, was founded 200 years ago in Israel by the

Al-Sayyid Bedouins. Within the last three generations, 150 deaf individuals were born into this community, all descended from two of the founders' five sons. ABSL was thus born. The language now has three generations of signers and offers the opportunity to not only observe a language in its infant stages but also watch it grow.

ABSL is not yet a mature language and thus is still undergoing rapid change. As a result, signers from each of the three generations are likely to differ, and to differ systematically, in the system of signs they use. By observing signers from each generation, we can therefore make good guesses as to when a particular linguistic property first entered the language. Moreover, because the individual families in the community are tightly knit, with strong bonds within families but not across them, we can chart changes in the language in relation to the social network of the community. We can determine when properties remained within a single family and when they did not, and thus follow the trajectory that particular linguistic properties took as they spread (or failed to spread) throughout the community. This small and self-contained community consequently offers a unique perspective on some classic questions in historical linguistics (Labov, 1994, 2001).

It is important to note, however, that even the first generation of signers used a system of signs characterized by segmentation and linearization (Meir *et al.*, 2010). In other words, the initial sign language did not look like co-speech gesture. In addition, highly regular sign order evolved to mark grammatical relations within the first generation; the particular order used is SOV. Interestingly, however, the language appears to have developed very little, if any, complex morphology (Aronoff *et al.*, 2004), a property found in all established sign languages studied thus far.

4.2.2.2 A deaf community sign language: Nicaraguan Sign Language

An example of a deaf community sign language is Nicaraguan Sign Language (NSL). NSL was created by deaf individuals who were brought together for the first time in the late 1970s and became the first-generation cohort (Kegl *et al.*, 1999; Senghas and Coppola, 2001). The signs that the first cohort uses are segmented, with each semantic primitive represented as an independent element. For example, first-cohort signers are more likely to convey manner and path in separate signs than in a single sign (the hand makes a circular movement *followed by* a downward movement, rather than the hand making a circular movement *simultaneously with* the downward movement, Senghas *et al.*, 2004). Moreover, first-cohort signers combine their signs, adhering to consistent word orders to convey who does what to whom (Senghas *et al.*, 1997).

But NSL has not stopped there. Every year, new students enter the school and learn to sign among their peers. This second cohort of signers has as its input the sign system developed by the first cohort and, interestingly, changes that input so that the product becomes more language-like. For example, although first-cohort signers occasionally describe events using individual manner and path signs presented sequentially, second-cohort signers do it more often (Senghas *et al.*, 2004). Similarly, first-cohort signers occasionally produce verbs with two or more arguments, but second-cohort signers use them more often (Senghas, 1995). Given this additional complexity, it seems quite natural that second-cohort signers go beyond the small set of basic word orders used by the first cohort, introducing new orders not seen previously in the language (Senghas *et al.*, 1997). Moreover, the second cohort begins to use spatial devices invented by the first cohort, but they use these devices consistently and for contrastive purposes (Senghas *et al.*, 1997; Senghas and Coppola, 2001). The second cohort, in a sense, stands on the shoulders of the first. They do not need to invent properties like segmentation and linearization – those properties are already present in their input. They can therefore take the transformation process one step further.

Like ABSL, NSL has arisen with no influence from any established language, either signed or spoken. However, NSL differs from ABSL in that the community within which it is developing is less socially stable, and the children learn their language from other members of the deaf community at school rather than from their parents at home. The differences and similarities between the two systems can thus provide useful information about the trajectories that emerging sign languages follow as they grow into a fully formed conventional system.

4.2.3 Homesign: The first step toward becoming a language

Emerging sign languages like ABSL and NSL hold a unique position between established sign languages and what has come to be known as *homesign* (Goldin-Meadow, 2003; 2009), a gesture system developed by a deaf child whose hearing losses prevent that child from acquiring spoken language and whose hearing parents have not exposed the child to a conventional sign language; that is, an individual gesture system not shared even with the hearing family members within that home. Established sign languages tell us where emerging sign languages are going. Homesign tell us where they may have started.

Despite their lack of a usable model of conventional language (and often despite intensive oral education), homesigners communicate and do so using gestures characterized by many, although not all, of the properties found in natural languages (Goldin-Meadow, 2003). For example, homesigners' gestures form a lexicon, and these lexical items are composed of parts, comparable in structure to a morphological system (Goldin-Meadow *et al.*, 1995; 2007). Moreover, the lexical items combine to form structured sentences, comparable in structure to a syntactic system (Feldman *et al.*, 1978; Goldin-Meadow and Mylander, 1984; 1998). In addition, homesigners use gestural lexical markers that modulate the meanings of their gesture sentences (negation and questions, Franklin *et al.*, 2011) and grammatical categories (nouns, verbs, and adjectives, Goldin-Meadow *et al.*, 1994). Homesigners display hierarchical structure in their sentences by building structure around the nominal constituent (Hunsicker and Goldin-Meadow, 2012) or by adding a second proposition to create a complex sentence (Goldin-Meadow, 1982). Finally, homesigners use their gestures not only to make requests of others, but also to comment on the present and non-present (Butcher *et al.*, 1991; Morford and Goldin-Meadow, 1997); to make generic statements about classes of objects (Goldin-Meadow *et al.*, 2005); to tell stories about real and imagined events (Morford, 1995; Phillips *et al.*, 2001); to talk to themselves (Goldin-Meadow 2003); and to talk about language (Goldin-Meadow, 1993) – that is, to serve typical functions that all languages serve, signed or spoken.

In countries like the United States, homesigners are likely to learn a conventional sign language at some later point in their lives, often around adolescence. However, in Nicaragua, many homesigners continue to use the gesture systems they create as children as their sole means of communication. Analyses of adult homesign in Nicaragua have uncovered linguistic structures that may turn out to go beyond the structures found in child homesign: the grammatical category subject (Coppola and Newport, 2005); pointing devices representing locations vs. nominals (Coppola and Senghas, 2010); morphophonological finger complexity patterns (Brentari *et al.*, 2012); and morphological devices that mark number (Coppola *et al.*, 2013). By contrasting the linguistic systems constructed by child and adult homesigners, we can see the impact that growing older has on language.

In addition, by contrasting the linguistic systems constructed by adult homesigners in Nicaragua with the structures used by the first cohort of NSL signers, we can see the impact that a community of users has on language. Having a group with whom they could communicate meant that the first cohort of signers were both producers and receivers of their linguistic system, a circumstance that could lead to a system with greater systematicity – but perhaps less complexity, as the group may need to adjust to the lowest common denominator.

Finally, by contrasting the linguistic systems developed by the first and second cohorts of NSL (e.g., Senghas, 2003), we can see the impact that passing a language through a new generation of learners has on language. Once learners are exposed to a system that has linguistic structure (i.e., cohort 2 and beyond), the processes of language change may be identical to the processes studied in historical linguistics. One interesting question is whether the changes seen in NSL in its earliest stages are of the same type and magnitude as the changes that occur in mature languages over historical time.

4.2.4 Hearing gesture: Input to homesign

A defining feature of homesign is that it is not shared in the way that conventional communication systems are. Deaf homesigners produce gestures to communicate with the hearing individuals in their homes. But the hearing individuals, particularly hearing parents who are committed to teaching their children to talk and thus to oral education, use speech back. Although this speech is often accompanied by gesture (Flaherty and Goldin-Meadow, 2010), as we have seen earlier, the gestures that co-occur with speech form an integrated system with that speech and, in this sense, are not free to take on the properties of the deaf child's gestures. As a result, although hearing parents respond to their deaf child's gestures, they do not adopt the gestures themselves (nor do they typically acknowledge that the child even uses gesture to communicate). The parents produce co-speech gestures, not homesigns.

Not surprisingly, then, the structures found in child homesign cannot be traced back to the spontaneous gestures that hearing parents produce while talking to their children (Goldin-Meadow and Mylander, 1983, 1984; Goldin-Meadow *et al.*, 1994, 1995). Homesigners see the global and unsegmented gestures that their parents produce. But when gesturing themselves, they use gestures that are characterized by segmentation and linearization. Although the gestures hearing individuals produce when they talk do not provide a model for the linguistic structures found in homesign, they could provide the raw materials for the linguistic constructions that homesigners build (see, for example, Goldin-Meadow *et al.*, 2007). As such, co-speech gesture could contribute to the picture of emerging sign languages that we are building (see Senghas *et al.*, 2004). Moreover, the disparity between co-speech gesture and homesign has important implications for language learning. To the extent that the properties of homesign differ from the properties of co-speech gesture, the deaf children themselves are likely to be imposing these particular structural properties on their communication systems. It is an intriguing, but as yet unanswered, question as to where the tendency to impose structure on homesign comes from.

Co-speech gestures do not assume the linguistic properties found in homesign. But what would happen if we were to ask hearing speakers to abandon speech and create a manual communication system on the spot? Would that system contain the linguistic properties found in homesign? Examining the gestures that hearing speakers produce when requested to communicate without speech allows us to explore the robustness of linguistic constructions created online in the manual modality.

Hearing gesturers asked to gesture without speaking are able to construct some properties of language with their hands. For example, the order of the gestures they construct on the spot indicates who does what to whom (Goldin-Meadow *et al.*, 1996; Gershkoff-Stowe and Goldin-Meadow, 2002). However, hearing gesturers do not display other linguistic properties found in established sign languages and even in homesign. For example, they do not use consistent form–meaning pairings akin to morphemes (Singleton *et al.*, 1993), nor do they use the same finger complexity patterns that established sign languages and homesign display (Brentari *et al.*, 2012).

Interestingly, the gestures that hearing speakers construct on the spot without speech do not appear to be derived from their spoken language. When hearing speakers of four different languages (English, Spanish, Chinese, Turkish) are asked to describe animated events using their hands and no speech, they abandon the order typical of their respective spoken languages and produce gestures that conform to the same order – SOV (e.g., captain-pail-swings; Goldin-Meadow *et al.*, 2008), the order found in ABSL (Sandler *et al.*, 2005). This order is also found when hearing speakers of these four languages perform a non-communicative, non-gestural task (Goldin-Meadow *et al.*, 2008). Recent work on English-, Turkish-, and Italian-speakers has replicated the SOV order in hearing gesturers, but finds that gesturers move away from this order when given a lexicon (either spoken or manual, Hall *et al.*, 2010); when asked to describe reversible events involving two animates (*girl pulled man*, Meir, Lifshitz *et al.*, 2010); and when asked to describe more complex events (*man tells child that girl catches fish*, Langus and Nespor, 2010). Studies of hearing gesturers give us the opportunity to manipulate conditions that have the potential to affect communication, and to then observe the effect of those conditions on the structure of the emerging language.

4.2.5 Do signers gesture?

We have seen that hearing speakers produce analog, imagistic signals in the manual modality (i.e., gesture) along with the segmented, discrete signals they produce in the oral modality (i.e., speech), and that these gestures serve a number of communicative and cognitive functions. The question we now ask is whether signers produce gestures and, if so, whether those gestures serve the same functions as co-speech gesture.

Deaf signers have been found to gesture when they sign (Emmorey, 1999; Sandler, 2003). But do they produce mismatches and do those mismatches predict learning? ASL-signing deaf children, asked to explain their solutions to the same math problems studied in hearing children (Perry *et al.*, 1988), turn out to produce gestures just as often as the hearing children. Moreover, the deaf children who produce many gestures conveying different information from their signs (i.e., gesture–sign mismatches) are more likely to succeed after instruction in ASL than the deaf children who produce few mismatches (Goldin-Meadow *et al.*, 2012).

These findings suggest not only that mismatch can occur within-modality (both sign and gesture use the manual modality), but that mismatch can predict learning in deaf signers just as it does in hearing speakers. Moreover, the findings suggest that juxtaposing different ideas across two modalities is *not* essential for mismatch to predict learning. Rather, it appears to be the juxtaposition of different ideas across two distinct representational formats – an analog format underlying gesture vs. a discrete and segmented format underlying words or signs – that is responsible for mismatch predicting learning. Finally, the findings pave the way for using gesture-based teaching strategies with deaf learners.

4.3 Conclusion

Humans are equipotential with respect to language-learning – if exposed to language in the manual modality, children will learn a sign language as quickly and effortlessly as they learn a spoken language. Why then has the oral modality become the modality of choice for languages around the globe? One hypothesis is that the oral modality might have triumphed over the manual modality simply because it is so good at encoding messages in the segmented and combinatorial form that human languages have come to assume. But as we have seen in our examination of sign language, the manual modality is just as good as the oral modality at segmented and combinatorial encoding. There is thus little to choose between sign and speech on these grounds. However, as we have seen in our examination of co-speech gesture, language serves another important function – it conveys information imagistically. The oral modality is not particularly well suited to this function, but the manual modality excels at it. It is possible, then, that the oral modality assumes the segmented and combinatorial format characteristic of all natural languages not because of its strengths, but to compensate for its weaknesses (Goldin-Meadow and McNeill, 1999).

Whatever role the manual modality has played in fashioning the way language looks today, it is clear that the hands have much to tell us about human functioning. The way speakers move their hands when they talk – co-speech gesture – provides insight into speakers' thoughts (thoughts they may not know they have) and can even play a role in changing those thoughts. The way signers move their hands when speech is not possible – as seen in both emerging and established sign languages – provides insight into the properties of language that define human language and the factors that have made human language what it is. How humans use the manual modality to communicate reveals a great deal about how we talk and think.

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