Gesture in all its forms

Following in the footsteps of Adam Kendon

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Adam Kendon has contributed to every facet of gesture studies, from the co-speech gestures that occur with talk, to the silent gestures that replace talk. This chapter describes work I have done that follows in Adam's footsteps. I first examine silent gesture in two groups: (1) children whose hearing losses prevent them from learning spoken language and whose hearing parents have not exposed them to sign language, and (2) hearing speakers asked to abandon their spoken language and use gesture to communicate – gesture when it becomes language. I then examine co-speech gesture, exploring how gesture works together with speech to help hearing children learn language (as well other topics) – gesture when it is part of language.

Introduction

Non-verbal behavior has traditionally been assumed to play a role in conveying a speaker's attitude toward the message or in regulating the interaction between speaker and listener (e.g. Argyle 1975; Wundt 1900/1973), rather than playing a role in conveying the message itself. According to this view, communication is divided into content-filled verbal and affect-filled non-verbal components.

Adam Kendon was the first to challenge the traditional view, arguing that at least one form of non-verbal behavior – gesture – cannot be separated from the content of the conversation. As Adam has shown in his elegant studies over the years, culminating in his 2004 book, the hand movements we produce as we talk are tightly intertwined with that talk in terms of timing, meaning, and function. To ignore the information conveyed in these hand movements, these gestures, is to ignore part of the conversation itself.

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Adam has contributed to every facet of gesture studies, from the gestures that speakers produce when they talk (Kendon 1980) to the gestures that individuals produce when they are unable to talk or are prevented from talking (Kendon 1998). In this chapter, I describe the work that I have done following in Adam's footsteps, with a focus on developmental processes, since I am a developmental psychologist.

I begin by looking at gesture when it takes the place of speech in two different populations. The first population is children who are congenitally deaf and cannot learn the spoken language that surrounds them. These children are born to hearing parents who have not exposed them to an established sign language. Not having a conventional language to model their communications after, the children turn to gesture to communicate. These gestures, called "homesigns," assume the full burden of communication and, interestingly, take on language-like forms – they are language.

The second population is hearing speakers who are asked to abandon their native spoken language and use gesture to communicate. I ask which properties of language these hearing speakers are able to invent on the spot – that is, how close do their "silent gestures" come to language.

I then look at gesture when it works together with speech to communicate in hearing children learning language from a spoken language model. These children produce gestures, as do all hearing speakers. Unlike the homesigns of deaf children and the silent gestures of hearing individuals, the gestures produced by hearing speakers share the burden of communication with speech and do not take on language-like forms – they are part of language and, as such, play a role not only in learning language, but also in learning other domains.

When gesture takes the place of speech to communicate

Homesigns in deaf children born to hearing parents

Deaf children with profound hearing losses have difficulty acquiring spoken language. If these children are exposed to sign language, they learn that language as naturally and effortlessly as hearing children learn spoken language. However, most deaf children are not born to deaf parents, who could provide them with input from a sign language from birth; 90% are born to hearing parents. These parents typically do not know sign language and would prefer that their deaf children learn the spoken language that they and their relatives speak. In the 1970s when my colleagues and I were beginning our studies, there were no cochlear implants and few schools in which sign language was taught and used. Many profoundly deaf children born to hearing parents were sent to oral schools for the deaf – schools that focused on developing the deaf child's oral potential, using visual and kinesthetic cues and eschewing sign language to do so. The deaf children we studied were, unfortunately, not able to achieve the kind of proficiency in spoken language that hearing children do, even with intensive instruction.

Not surprisingly, deaf children who are unable to learn spoken language and have not yet been exposed to sign language turn to gesture to communicate – the manual modality is the only modality easily accessible to them, and they are likely to see gesture used in communicative contexts when their hearing parents talk to them. The question we were interested in was whether homesigners use gestures in the same way that the hearing speakers who surround them do (i.e. as though they were accompanying speech), or whether they refashion their gestures into a linguistic system reminiscent of the sign languages of deaf communities.

We found that, like hearing children at the earliest stages of language learning, homesigners use both pointing gestures and iconic gestures to communicate. The difference between homesigners and hearing children is that, as they get older, homesigners' gestures blossom – they begin to take on the functions and forms that are typically assumed by conventional language, spoken or signed.

Homesigns resemble language in function

Homesigners use gesture to request objects and actions from others. For example, one child pointed at a bubble jar and gestured "twist" to ask his mother to twist open the jar. They also use gesture to comment on the actions and attributes of objects and people in the room. For example, a child gestured "march" and then pointed at a wind-up toy soldier to comment on the fact that the soldier was, at that very moment, marching.

Among language's most important functions is making reference to objects and events that are not perceptible to either the speaker or the listener – displaced reference (cf. Hockett 1960). Homesigners use gesture to serve this function as well, communicating about non-present objects and events (Butcher, Mylander & Goldin-Meadow 1991; Morford & Goldin-Meadow 1997). For example, one homesigner produced the following string of gesture sentences to indicate that the family was going to move a chair downstairs in preparation for setting up a cardboard Christmas chimney: He pointed at the chair and then gestured "move-away". He pointed at the chair again and pointed downstairs where the chair was going to be moved to. He gestured "chimney," "move-away" (produced in the direction of the chair) and "move-here" (produced in the direction of the cardboard chimney). Homesigners also use gesture to tell stories (Phillips, Goldin-Meadow & Miller 2001), to talk to themselves (Goldin-Meadow 2003a), and to comment on their own and others' gestures (Singleton, Morford & Goldin-Meadow 1993).

Homesigns resemble language in form

In addition to assuming the functions of language, homesign assumes its forms. Homesigners combine their gestures into strings that have many of the properties of signed sentences. Some of these "sentences" convey a single proposition (Goldin-Meadow & Feldman 1977). For example, one homesigner pointed at a snack, produced an "eat" gesture, and then pointed at the experimenter to invite her to join in the snack. Other gesture sentences convey more than one proposition and, in this sense, can be considered complex sentences (Goldin-Meadow 1982). For example, a homesigner produced the following gesture sentence to indicate that he would clap the bubble to burst it (proposition 1) after his mother twisted open the bubble jar (proposition 2) and blew it (proposition 3): He gestured "clap," pointed at himself, gestured "twist" then "blow," and pointed at his mother. Homesigners also modulate their gesture sentences, adding negative markers (side-to-side headshakes) to the beginnings of sentences, and question markers (rotate palm down to palm up) to the ends (Franklin, Giannakidou & Goldin-Meadow 2011).

Homesigners' gesture combinations are structured at underlying levels (Goldin-Meadow 1985). For example, the framework underlying a gesture sentence about giving, in addition to the predicate *give,* contains three arguments – the *giver* (actor), the *given* (patient) and the *givee* (recipient). In contrast, the framework underlying a sentence about eating, in addition to the predicate *eat,* contains two arguments – the *eater* (actor) and the *eaten* (patient). These underlying frameworks influence how likely it is that a homesigner will produce a gesture for a particular argument, and the likelihood with which gestures are produced provides evidence for the underlying frameworks.

Homesigners' gesture combinations are also structured at surface levels, containing many of the devices to mark "who does what to whom" that are found in the early sentences of hearing children (Goldin-Meadow & Mylander 1984, 1998; Goldin-Meadow, Butcher, Mylander & Dodge 1994). Homesigners indicate objects that play different thematic roles by means of three different devices: (1) by preferentially producing (as opposed to omitting) gestures for objects playing particular roles (e.g. pointing at the drum, the patient, as opposed to the drummer, the actor); (2) by placing gestures for objects playing particular roles in set positions in a gesture sentence (e.g. producing the gesture for the patient, "drum," before the gesture for the act, "beat"); or (3) by displacing verb gestures toward objects playing particular roles (e.g. producing the "beat" gesture near the patient, drum). The deaf children's gesture combinations therefore adhere to rules of syntax, albeit simple ones.

Homesigners' gestures thus have a set of elements (gestures) that combine systematically to form novel larger units (sentences). Importantly, this combinatorial feature is found at a second level – the gestures that combine to form sentences are themselves composed of parts (morphemes). For example, each gesture in a deaf child's repertoire is composed of a handshape component (e.g. an O-handshape representing the roundness of a penny) and a motion component (e.g. a short arc motion representing a putting down action). The meaning of the gesture as a whole is a combination of the meanings of its parts ("round-put-down" (Goldin-Meadow et al. 1995; 2007)).

Homesigns also have grammatical categories – gestures serving noun-like functions are different in form from gestures serving verb-like functions (Goldin-Meadow et al. 1994). For example, when a deaf child uses a "twist" gesture as a verb in a sentence meaning "twist-open the jar," he is likely to produce the gesture (a) without abbreviation (with several rotations rather than one), and (b) with inflection (the gesture is directed toward a relevant object, in this case, the jar). In contrast, when the child uses the "twist" gesture as a noun in a sentence meaning "that's a twistable object, a jar," he is likely to produce it (a) with abbreviation (with one rotation rather than several), and (b) without inflection (in neutral space rather than directed at an object).

In addition, noun gestures are, at times, produced along with pointing gestures that act like demonstratives (Hunsicker & Goldin-Meadow 2012); for example, pointing at a bird, followed by a noun gesture for "bird" (flapping arms at sides), followed by a verb gesture for "pedal," used to describe a picture of a bird pedaling a bicycle. The pointing gesture specifies which member of the class of birds is doing the pedaling and, in this sense, forms a unit with the noun, that is, "[that bird] pedals," akin to a nominal constituent containing a demonstrative ("that") and a noun ("bird"). Importantly, these point plus noun units function both semantically and syntactically like complex nominal constituents in spoken and signed languages, suggesting that homesign has hierarchical structure.

Homesigns are just the beginning

Homesigning children have gesture systems that contain many of the basic properties found in all natural languages. But child homesign is not a full-blown language, and for good reason. The children are inventing their gesture systems on their own without a community of communication partners. Indeed, when homesign children were brought together when the first school for the deaf was opened in Nicaragua in the late 1970s, their gesture systems began to cohere into a recognizable and shared language. That language, Nicaraguan Sign Language, NSL, became increasingly complex, particularly after a new generation of deaf children learned the system as a native language (Kegl, Senghas & Coppola 1999).

The circumstances in Nicaragua permit us to go beyond uncovering skills children bring to language learning to gain insight into where those skills fall short; that is, to discover which properties of language are so fragile that they cannot be developed by a child lacking access to a conventional language model (Goldin-Meadow 2010). By comparing current-day child homesigners in Nicaragua with groups whose circumstances have allowed them to go beyond child homesign, we can determine which conditions foster the development of these relatively fragile linguistic structures.

1. We can observe changes made to the system when it remains the homesigner's sole means of communication into adulthood (e.g. Coppola & Newport 2005; Brentari, Coppola, Mazzoni & Goldin-Meadow 2012). Studying adult homesigners allows us to explore the impact that cognitive and social maturity have on linguistic structure.
2. We can observe changes made to the system when it becomes a community-wide language, as homesigners come together for the first time (Coppola & Senghas 2010; Senghas, Ozyurek & Goldin-Meadow 2010). Studying the signers who originated NSL allows us to explore the impact that a community in which signers not only produce but also receive their communication has on linguistic structure.
3. We can observe changes made to the system when it is passed through subsequent generations of learners (Senghas 2003; Senghas & Coppola 2001). Studying generations of NSL signers allows us to explore the impact that passing a newly birthed language through new learners has on linguistic structure.
4. Finally, as a backdrop, we can study the gestures that hearing speakers produce, both with speech (Senghas, Kita & Ozyurek 2004) and without it (Brentari et al. 2012; Goldin-Meadow, So, Ozyurek & Mylander 2008), to better understand the raw materials out of which these newly emerging linguistic systems have risen. The manual modality can take on linguistic properties, even in the hands of a young child not yet exposed to a conventional language model. But it grows into a full-blown language only with the support of a community that can transmit the system to the next generation.

Homesigns do not look like hearing speakers' gestures

The homesigners described earlier had not been exposed to a conventional sign language and thus could not have fashioned their gesture systems after such a model. They were, however, exposed to the gestures that their hearing parents used when they talked to them. These parents were committed to teaching their children English and therefore talked to them as often as they could. And when they talked, they gestured. The parents' gestures might have displayed the language-like properties found in their children's gestures. It turns out, however, that they did not (Goldin-Meadow & Mylander 1983, 1984; Goldin-Meadow et al. 1994, 1995, 2007; Hunsicker & Goldin-Meadow 2012). The gestures that the homesigners' hearing parents produced looked just like any other hearing speaker's gestures, and thus different from their children's gestures.

Why didn't the hearing parents display language-like properties in their gestures? In a sense, the deaf children's hearing parents did not have the option of displaying these properties in their gestures simply because the parents produced all of their gestures with talk. Their gestures formed a single system with the speech they accompanied. As Kendon (1980) has so aptly shown, gesture has to fit, both temporally and semantically, with the speech it accompanies – the parents' gestures were not "free" to take on language-like properties. In contrast, the deaf children had no such constraints on their gestures. They had essentially no productive speech and thus always produced gesture on its own, without talk. Moreover, because gesture was the only means of communication open to these children, it had to take on the full burden of communication. The result was language-like structure.

But what would happen if hearing speakers were told not to speak and to use only their hands to communicate? Once speech is removed, gesture must stand on its own to fulfil the burden on communication. Do these silent gestures take on new forms to accommodate their new functions, and, if so, do the forms display structures comparable to those observed in homesign? This is the question to which we now turn.

Silent gestures in hearing speakers asked not to talk

Silent gestures display consistent word order

Silent gestures are created in the moment and have no history. Silent gestures were first mined for word order in a wide range of countries – the U.S., China, Turkey, Spain (Goldin-Meadow et al. 2008), Italy (Langus & Nespor 2010), Israel (Meir, Lifshitz, Ilkbasaran & Padden 2010), Japan and Korea (Gibson et al. 2013). Despite the fact that the canonical word orders for simple transitive sentences in the languages spoken in these countries differ, the gesture order used by the silent gesturers to describe a prototypical event encoded in a transitive sentence (i.e. an animate acting on an inanimate) is identical in all countries. Silent gesturers around the globe first produce a gesture for the animate doer, then a gesture for the inanimate done-to, and finally a gesture for the action that relates the two, an order reminiscent of the Subject-Object-Verb (SOV) order found in roughly half the world's languages (Baker 2001; Dryer 2005).

Interestingly, although direction of change is difficult to assess over historical time, SOV has been hypothesized to predominate in the early stages of spoken (Givon 1979; Newmeyer 2000) and signed (Fisher 1975) languages. Even more relevant, SOV is the order currently emerging in a sign language developed without any apparent external influence. Al-Sayyid Bedouin Sign Language has arisen within the last 70 years in an isolated community with a high incidence of profound prelingual deafness; in the space of one generation, the language has assumed grammatical structure, including SOV order (Sandler, Meir, Padden & Aronoff 2005). In addition, homesigns in both the U.S. (Goldin-Meadow & Feldman 1977) and China (Goldin-Meadow & Mylander 1998) display OV order (homesigners rarely produce gestures for transitive actors, the S).

The fact that silent gesturers do not borrow the word order of their spoken language and instead adopt a totally new (and seemingly fundamental) order suggests that silent gestures are not a mere translation into the manual modality of the language that the gesturer routinely speaks. Rather, silent gesture seems to reflect the construction of new forms on the spot. Finding that silent gesture does assume some of the properties of language, we can then ask whether it assumes them all – or at least all of the linguistic properties found in homesign.

Silent gestures use location to establish co-reference

All sign languages studied thus far use space to indicate referents and the relations among them (Mathur & Rathmann 2010). These uses of space lay the foundation for maintaining coherence in a discourse. In American Sign Language, a signer can associate a spatial location with an entity and later articulate a sign with respect to that location to refer back to the entity, akin to coreference in a spoken language (e.g. "Bert yelled at Ernie and then apologized to him," where *him* refers back to *Ernie*). As an example from sign language, after associating a location in space with Ernie, a signer can later produce a verb with respect to that space to refer back to Ernie without repeating the sign for Ernie (Padden 1988). By using the same space for an entity throughout a discourse, signers maintain coreference. Coreference is an important function in all languages (Bosch 1983) and is considered a "core" property of grammar (Jackendoff 2002). Using space for coreference is found not only in well-established sign languages, but also in the first cohort of NSL (Senghas & Coppola 2001) and in adult homesigners (Flaherty, Goldin-Meadow, Senghas & Coppola 2013).

Will hearing speakers asked to communicate using only their hands construct this same device immediately? So and colleagues (2005) instructed adults to describe scenes using gesture and no speech. One group saw events presented in an order that told a story (connected events); the other group saw the same events in random order interspersed with events from other stories (unconnected events). The adults used space coreferentially – they established a location for a character with one gesture and then re-used that location in subsequent gestures to refer back to the character. Moreover, they used space coreferentially more often when describing connected events (i.e. when they could use the same spatial framework throughout the story) than when describing unconnected events.

Interestingly, when the adults were asked to describe the same events in speech, they did not use their co-speech gestures (i.e. the gestures that they produced along with speech) coreferentially any more often for connected events than for unconnected events, suggesting that hearing individuals use space coreferentially particularly when their gestures are forced to assume the full burden of communication.

Silent gestures do not display segmentation in manner and path motion forms

Sign languages often contain separate lexical items for manner (*roll*) and path (*down*) despite the fact that these two aspects of crossing-space events occur simultaneously (when a ball rolls down an incline, the rolling manner occurs throughout the downward path). Senghas, Kita and Ozyurek (2004) found evidence of manner/path segmentation in the earliest cohorts of NSL. Members of Cohort 1 analyzed complex motion events into basic elements and, when they referred to manner and path within a single gesture string, they *sequenced* these elements into structured expressions (e.g. *roll-down*), although they did so less often than members of Cohorts 2 and 3. Importantly, this type of segmentation was not observed in the gestures that Nicaraguan Spanish speakers produced along with their speech. The hearing speakers *conflated* manner and path into a single gesture (i.e. *roll + down,* a rolling movement made while moving the hand downward).

Although there are no data available at the moment from Nicaraguan homesigners to address this question, Ozyurek, Furman, and Goldin-Meadow (2014) asked child homesigners in Turkey to describe animated motion events, and compared their gestures to the co-speech gestures produced by hearing adults (including their own mothers) and hearing children in the same community. The most frequent response for the hearing speakers, adults and children alike, was a path gesture used on its own (e.g. *down*). Homesigners produced path-alone gestures too, but they also produced many gesture strings conveying both manner and path that were either conflated (e.g. *roll + down*) or a combination of conflated and sequenced (e.g. *roll + down–down*) forms.

Is motion segmentation found in silent gesturers? After describing the events in speech, the hearing adults in Ozyurek et al.'s (2014) study were asked to describe the events again, this time using only their hands. When using only gesture and no speech, the silent gesturers increased the number of gesture strings they produced containing both manner and path. They thus resembled the homesigners in *what* they conveyed. However, they differed from the homesigners in *how* they conveyed it – the silent gesturers produced more conflated forms (*roll + down*) than the homesigners, but fewer combinations of conflated and sequenced forms (*roll + down–roll*). Silent gesturers were less likely to experiment with segmentation than the homesigners, relying for the most part on conflation when expressing both manner and path. The conflated form is a more transparent mapping of the actual event in that the manner of motion occurs simultaneously throughout the path. The fact that silent gesturers rarely use segmentation when conveying motion indicates that segmentation of action forms is not a routine feature of communication invented on the spot. Action segmentation may well require time and repeated use to emerge.

Silent gestures do not display the finger complexity patterns found in conventional sign languages

Sign language classifiers are closest in function to verb classifiers in spoken languages, and are heavily iconic. The handshape is an affix on the verb and can either represent properties of the object itself (object classifiers) or properties of the hand as it handles the object (handling classifiers). Despite the iconicity found in the handshapes used in classifier predicates (e.g. a round handshape is used to represent round objects in American Sign Language), these handshapes have morphological structure – they are discrete, meaningful, productive forms that are stable across related contexts (Supalla 1982; Eccarius 2008). Interestingly, there are commonalities across different sign languages in terms of how handshape is used in classifier predicates. In all sign languages studied to date, finger complexity tends to be higher in object classifier handshapes than in handling classifier handshapes (Brentari & Eccarius 2010; Eccarius 2008). The same pattern has been found in adult homesigners in Nicaragua (Brentari, Coppola, Mazzoni & Goldin-Meadow 2012).

Do silent gesturers display this finger complexity pattern? Brentari and colleagues (2012) explored this question in silent gesturers in Italy and the United States, and found that the silent gesturers in both countries did *not* display this pattern – the handshapes they produced to represent objects (akin to object classifiers) had *less* finger complexity than the handshapes they produced to represent handling the objects (akin to handling classifiers). These findings suggest that the pattern found in established sign languages – and homesign – is not a codified version of the pattern invented by hearing individuals on the spot.

When asked to use gesture on its own, silent gesturers do not use gesture as they typically do when they speak. Rather, they transform their gestures into a system that has some, but not all, of the linguistic properties found in homesign. This transformation may be comparable in some ways to the transformation that homesigners perform when they take the gestures that they see in the hearing world and turn them into homesign (Goldin-Meadow 2003a,b), but it differs in other ways, likely because homesigners differ from silent gesturers on several important dimensions. First, homesigners do not have access to a usable linguistic model; silent gesturers have all learned and routinely use a spoken language (although there is no evidence that they recruit that language when fashioning their silent gestures (Goldin-Meadow et al. 2008; Langus & Nespor 2010; Meir et al. 2010; Gibson et al. 2013)). Second, homesigners have been using their gestures for many years; silent gesturers create their gestures on the spot. The differences found between the gestures generated by homesigners versus silent gesturers thus point to the potential importance of these two factors – linguistic input and time – in the development of a language system.

When gesture works with speech to communicate

We are now in a position to appreciate just how versatile the manual modality is – it can take on linguistic properties when called upon to do so, but it can also assume a non-segmented global form when it accompanies speech. This versatility is important simply because it tells us that the form gesture assumes is not entirely determined by the manual modality. It seems to be determined by the functions gesture serves, and thus has the potential to inform us about those functions. And we do find that speech-accompanying gestures can provide insight into how the mind works.

Gesture becomes integrated with speech during the one-word period and predicts future linguistic milestones

Children use gesture to communicate early in development, often before they produce their first words. The proportion of a child's communications containing gesture remains relatively constant throughout the single-word period, but what changes during this time period is the relationship that gesture holds to speech. At the beginning of the one-word period, three properties characterize children's gestures:

1. Gesture is frequently produced alone; that is, without any vocalizations at all, either meaningless sounds or meaningful words.
2. On the rare occasions when gesture is produced with a vocalization, it is combined only with meaningless sounds and not with words; this omission is striking given that the child is able to produce meaningful words without gesture during this period.
3. The few gesture-plus-meaningless sound combinations that the child produces are not timed in an adult fashion; that is, the sound does not occur on the stroke or the peak of the gesture (Kendon 1980; McNeill 1992).

Some time during the one-word period, two notable changes take place in the relationship between gesture and speech (Butcher & Goldin-Meadow 2000). First, gesture-alone communications decrease and, in their place, the child begins to produce gesture-plus-meaningful-word combinations for the first time. Gesture and speech thus begin to have a *coherent semantic relationship* with one another. Second, gesture becomes synchronized with speech, not only with the meaningful words that comprise the novel combinations but also, importantly, with the old combinations that contain meaningless sounds (in other words, temporal synchronization applies to both meaningful and meaningless units and is therefore a separate phenomenon from semantic coherence). Thus, gesture and speech begin to have a *synchronous temporal relationship* with one another. These two properties – semantic coherence and temporal synchrony – characterize the integrated gesture-speech system found in adults (McNeill 1992) and appear to have their origins during the one-word period.

The onset of gesture-speech integration sets the stage for a new type of gesture-speech combination – combinations in which gesture conveys information that is different from the information conveyed in speech. For example, a child can gesture at an object while describing the action to be done to that object in speech (pointing to an cookie and saying "give"), or may gesture at an object while describing the owner of that object in speech (pointing at a hat and saying "mama") (Greenfield & Smith 1976). This type of gesture-speech combination allows a child to express two elements of a proposition (one in gesture and one in speech) at a time when the child is not yet able to express those elements within a single spoken utterance. Children begin to produce combinations in which gesture conveys different information from speech (e.g. point at bird and say "nap") at the same time as, or later than – but *not* before – combinations in which gesture and speech convey the same information (point at bird and say "bird") (Goldin-Meadow & Butcher 2003). Thus, combinations in which gesture and speech convey different information are not produced until *after* gesture and speech become synchronized, and thus appear to be a product of an integrated gesture-speech system (rather than a product of two systems functioning independently of one another).

In turn, combinations in which gesture and speech convey different information predict the onset of two-word combinations. Children who are the first to produce combinations in which gesture and speech convey different information are also the first to produce two-word combinations (Goldin-Meadow & Butcher 2003; Iverson & Goldin-Meadow 2005). Importantly, the correlation between gesture-speech combinations and two-word speech is specific to combinations in which gesture and speech convey *different* information (point at bird and say "nap"); the correlation between the age of onset of combinations in which gesture and speech convey the *same* information (point at bird and say "bird") and the age of onset of two-word combinations is low and unreliable. It is the *relationship* that gesture holds to speech that matters, not merely gesture's presence.

Gesture continues to predict future cognitive achievements over the course of development

Over time, children become proficient users of their spoken language. At the same time, rather than dropping out of children's communicative repertoires, gesture itself continues to develop and play an important role in communication. Older children frequently use hand gestures as they speak (Jancovic, Devoe & Wiener 1975), gesturing, for example, when asked to narrate a story (e.g. McNeill 1992), give directions (e.g. Iverson 1999) or explain their reasoning on a series of problems (e.g. Church & Goldin-Meadow 1986).

As in earlier stages, older children often use their hands to convey information that overlaps with the information conveyed in speech. Take, for example, a child participating in a Piagetian conservation task. The child is asked whether the amount of water changed when it was poured from a tall, skinny container into a short, wide container. The child says that the amount of water did change "cause that's down lower than that one," while first pointing at the relatively low water level in the short, wide container and then at the higher water level in the tall, skinny container. The child is focusing on the height of the water in both speech and gesture and, in this sense, has produced a *gesture-speech match*.

However, children also use their gestures to introduce information that is not found in their speech. Consider another child who gave the same response in speech, "cause this one's lower than this one," but indicated the *widths* (not the heights) of the containers with her hands (two C-shaped hands held near the relatively wide diameter of the short, wide container, followed by a left C-hand held near the narrower diameter of the tall, skinny container). In this case, the child is focusing on the height of the water in speech but on its width in gesture, and has produced a *gesture-speech mismatch*.

As in the early stages of language development, gesture and speech adhere to the principles of gesture-speech integration described by Kendon (1980), even when the two modalities convey different information. Consider a child who says the amount is different because the water in the short wide container is "lower," while indicating the width of the container in her gestures. Although this child is indeed expressing two different pieces of information in gesture and speech, she is nevertheless describing the same object in the two modalities. Moreover, the timing of the gesture-speech mismatch also reflects an integrated system. The child produces the width gesture as she says "this one's lower," thus synchronously expressing her two perspectives on the container.

Further evidence that gesture-speech mismatches reflect an integrated system comes from the fact that, as in the transition from one- to two-word speech, the relationship between gesture and speech is a harbinger of the child's next step. Children who produce many gesture-speech mismatches when explaining their solutions to a task appear to be in a transitional state with respect to that task – they are more likely to profit from instruction and make progress in the task than children who produce few mismatches. Gesture serves as an index of readiness-to-learn not only for conservation but for other tasks as well – for example, mathematical equivalence as it applies to addition (Perry, Church & Goldin-Meadow 1988), or balancing a beam on a fulcrum (Pine, Lufkin & Messer 2004). If gesture and speech were independent of one another, their mismatch would be a random event and, as a result, should have no cognitive consequence whatsoever. The fact that gesture-speech mismatch is a reliable index of a child's transitional status suggests that the two modalities are, in fact, *not* independent of one another.

Gesture not only reflects thought but can play a role in changing thought

Gesture offers a route, and a unique one, through which new information can be brought into the system. Because the representational formats underlying gesture are mimetic and analog rather than discrete, gesture permits learners to represent ideas that lend themselves to these formats (e.g. shapes, sizes, spatial relationships) – ideas that, for whatever reason, may not be easily encoded by that learner in speech. The suggestion here is that gesture does not just *reflect* the incipient ideas a learner has, but may actually help the learner formulate and therefore *develop* these new ideas. To determine whether gesturing helps children learn, we need to manipulate the gestures they produce on a task and observe the effect of that manipulation on their subsequent performance of the task.

Broaders, Cook, Mitchell and Goldin-Meadow (2007) asked 9- to 10-year old children to explain how they solved six mathematical equivalence problems (e.g. $6+4+2=\_\_+2$) 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 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, the children who had been told to gesture and had added strategies to their repertoires 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.

But can gesture, on its own, create new ideas? To determine whether gesture can create new ideas, we need to teach learners to move their hands in particular ways. If learners can extract meaning from their hand movements, they should be sensitive to the particular movements they are taught to produce, and should learn accordingly. Alternatively, all that may matter is that learners move their hands. If so, they should learn regardless of which movements they produce. To investigate these alternatives, Goldin-Meadow, Cook and Mitchell (2009) manipulated gesturing during a math lesson. They found that children required to produce *correct* gestures learned more than children required to produce *partially correct* gestures, who learned more than children required to produce *no* gestures. This effect was mediated by whether, after the lesson, the children added information to their spoken repertoire that they had conveyed uniquely in their gestures during the lesson (and that the teacher had not conveyed at all). The findings suggest that gesture is involved not only in processing old ideas, but also in creating new ones.

Gesturing not only helps children learn in the short-term, but it also makes learning last. Cook, Mitchell and Goldin-Meadow (2008) taught some children a strategy for solving mathematical equivalence problems in speech alone, some the same strategy in gesture alone, and a third group the strategy in both speech and gesture. The children produced the words and/or gestures they were taught throughout a lesson in how to solve the problems. Children in all three groups improved an equal amount after the lesson, but only the children who gestured during the lesson (either alone or with speech) retained what they had learned a month later. Gesturing, but not speaking, thus solidified the knowledge gained during instruction, suggesting that gesturing can play a causal role in learning.

In recent work, Novack, Congdon, Hemani-Lopez and Goldin-Meadow (2014) asked whether gesturing promotes learning because it is itself a physical action, or because it uses physical action to represent abstract ideas. They taught third-grade children a strategy for solving mathematical equivalence problems that was instantiated in one of three ways: (1) in the physical action children performed on objects, (2) in a concrete gesture miming that action, or (3) in an abstract gesture. All three types of hand movements helped children learn how to solve the problems on which they were trained. However, only gesture led to success with problems that required generalizing the knowledge gained, with abstract gesture producing the highest rates of learning on generalization problems. The results provide evidence that gesture promotes transfer of knowledge better than action, and suggest that the beneficial effects gesture has on learning may reside in the features that differentiate it from action.

Conclusion

No one has done more to promote the study of gesture than Adam Kendon. In addition to introducing a new way of looking at and thinking about gesture, Adam was instrumental in beginning the thriving International Society for Gesture Studies and in inaugurating the journal *Gesture*, which he has edited with great wisdom for 12 years. The work that I have done over the years on gesture when it replaces language and when it seamlessly works together with language all has its roots in Adam's research. The field, and I personally, owe him a great deal. The burgeoning world of gesture studies that is gaining steam with every generation of new young researchers is Adam Kendon's legacy.

References

Argyle, M. 1975. *Bodily Communication*. New York: International Universities Press.
Baker, M. C. 2001. *The Atoms of Language*. New York: Basic Books.
Bosch, P. 1983. *Agreement and Anaphora: A Study of the Roles of Pronouns in Discourse and Syntax*. London: Academic Press.
Brentari, D., Coppola, M., Mazzoni, L., and Goldin-Meadow, S. 2012. "When does a system become phonological? Handshape production in gesturers, signers, and homesigners." *Natural Language and Linguistic Theory* 30: 1–31. DOI: 10.1007/s11049-011-9145-1
Broaders, S., Cook, S. W., Mitchell, Z., and Goldin-Meadow, S. 2007. "Making children gesture reveals implicit knowledge and leads to learning." *Journal of Experimental Psychology: General* 136: 539–550. DOI: 10.1037/0096-3445.136.4.539
Butcher, C., and Goldin-Meadow, S. 2000. "Gesture and the transition from one- to two-word speech: When hand and mouth come together." In *Language and Gesture*, D. McNeill (ed.), 235–257. New York: Cambridge University Press. DOI: 10.1017/CBO9780511620850.015
Butcher, C., Mylander, C., and Goldin-Meadow, S. 1991. "Displaced communication in a self-styled gesture system: Pointing at the non-present." *Cognitive Development* 6: 315–342. DOI: 10.1016/0885-2014(91)90042-C
Church, R. B., and Goldin-Meadow, S. 1986. "The mismatch between gesture and speech as an index of transitional knowledge." *Cognition* 23: 43–71. DOI: 10.1016/0010-0277(86)90053-3
Cook, S. W., Mitchell, Z., and Goldin-Meadow, S. 2008. "Gesturing makes learning last." *Cognition* 106: 1047–1058. DOI: 10.1016/j.cognition.2007.04.010
Coppola, M., and Newport, E. 2005. "Grammatical subjects in homesign: Abstract linguistic structure in adult primary gesture systems without linguistic input." *Proceedings of the National Academy of Sciences* 102: 19249–19253. DOI: 10.1073/pnas.0509306102
Coppola, M., and Senghas, A. 2010. "Deixis in an emerging sign language." In *Sign Languages: A Cambridge Language Survey*, D. Brentari (ed.), 543–569. Cambridge: Cambridge University Press. DOI: 10.1017/CBO9780511712203.025
Dryer, M. 2005. "Order of subject, object and verb." In *The World Atlas of Language Structures*, M. Haspelmath, M. S. Dryer, D. Gil and B. Comrie (eds), 330–333. Oxford: Oxford University Press.
Eccarius, P. 2008. *A Constraint-Based Account of Handshape Contrast in Sign Languages*. Ph.D. dissertation, Purdue University.
Fisher, S. 1975. "Influences on word order change in American Sign Language." In *Word Order and Word Order Change*, C. Li (ed.), 1–25. Austin: University of Texas Press.
Flaherty, M., Goldin-Meadow, S., Senghas, A., and Coppola, M. 2013. "Watching minds shape language: The emergence of spatial verb agreement in Nicaraguan Sign Language." Poster presented at the *Budapest CEU Conference on Cognitive Development*, Budapest, Hungary, January 2013.
Franklin, A., Giannakidou, A., and Goldin-Meadow, S. 2011. "Negation, questions, and structure building in a homesign system." *Cognition* 118 (3): 398–416. DOI: 10.1016/j.cognition.2010.08.017
Gibson, E., Piantadosi, S. T., Brink, K., Bergen, L., Lim, E., and Saxe, R. 2013. "A noisy-channel account of crosslinguistic word order variation." *Psychological Science* 24: 1079–1088 DOI: 10.1177/0956797612463705
Givon, T. 1979. *On Understanding Grammar*. New York: Academic Press.

Goldin-Meadow, S. 1982. "The resilience of recursion: A study of a communication system developed without a conventional language model." In *Language Acquisition: The State of the Art*, E. Wanner and L. R. Gleitman (eds), 51–77. New York: Cambridge University Press.

Goldin-Meadow, S. 1985. "Language development under atypical learning conditions: Replication and implications of a study of deaf children of hearing parents." In *Children's Language*, Vol. 5, K. Nelson (ed.), 197–245. Hillsdale, NJ: Lawrence Erlbaum Associates.

Goldin-Meadow, S. 2003a. *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. 2003b. *Hearing Gesture: How Our Hands Help Us Think*. Cambridge, MA: Harvard University Press.

Goldin-Meadow, S. 2010. "Widening the lens on language learning: Language in deaf children and adults in Nicaragua." *Human Development* 53: 235–312. DOI: 10.1159/000321294

Goldin-Meadow, S., and Butcher, C. 2003. "Pointing toward two-word speech in young children." In *Pointing: Where Language, Culture, and Cognition Meet*, S. Kita (ed.), 85–107. Hillsdale, NJ: Lawrence Erlbaum Associates.

Goldin-Meadow, S., Butcher, C., Mylander, C., and Dodge, M. 1994. "Nouns and verbs in a self-styled gesture system: What's in a name?" *Cognitive Psychology* 27: 259–319. DOI: 10.1006/cogp. 1994.1018

Goldin-Meadow, S., Cook, S. W., and Mitchell, Z. A. 2009. "Gesturing gives children new ideas about math." *Psychological Science* 20: 267–272. DOI: 10.1111/j.1467-9280.2009.02297.x

Goldin-Meadow S., and Feldman, H. 1977. "The development of language-like communication without a language model." *Science* 197: 401–403. DOI: 10.1126/science.877567

Goldin-Meadow, S., and Mylander, C. 1983. "Gestural communication in deaf children: The non-effects of parental input on language development." *Science* 221: 372–374. DOI: 10.1126/science.6867713

Goldin-Meadow, S., and Mylander, C. 1984. "Gestural communication in deaf children: The effects and non-effects of parental input on early language development." *Monographs of the Society for Research in Child Development* 49: 1–121. DOI: 10.2307/1165838

Goldin-Meadow, S., and Mylander, C. 1998. "Spontaneous sign systems created by deaf children in two cultures." *Nature* 91: 279–281. DOI: 10.1038/34646

Goldin-Meadow, S., Mylander, C., and Butcher, C. 1995. "The resilience of combinatorial structure at the word level: Morphology in self-styled gesture systems." *Cognition* 56: 195–262. DOI: 10.1016/0010-0277(95)00662-I

Goldin-Meadow, S., Mylander, C., and Franklin, A. 2007. "How children make language out of gesture: Morphological structure in gesture systems developed by American and Chinese deaf children." *Cognitive Psychology* 55: 87–135. DOI: 10.1016/j.cogpsych.2006.08.001

Goldin-Meadow, S., So, W.-C., Ozyurek, A., and Mylander, C. 2008. "The natural order of events: How speakers of different languages represent events nonverbally." *Proceedings of the National Academy of Sciences* 105 (27): 9163–9168. DOI: 10.1073/pnas.0710060105

Greenfield, P., and Smith, J. 1976. *The Structure of Communication in Early Language Development*. New York: Academic Press.

Hockett, C. F. 1960. "The origin of speech." *Scientific American* 203 (3): 88–96. DOI: 10.1038/scientificamerican0960-88

Hunsicker, D., and Goldin-Meadow, S. 2012. "Hierarchical structure in a self-created communication system: Building nominal constituents in homesign." *Language* 88 (4): 732–763. DOI: 10.1353/lan.2012.0092

Iverson, J. M. 1999. "How to get to the cafeteria: Gesture and speech in blind and sighted children's spatial descriptions." *Developmental Psychology* 35: 1132–1142. DOI: 10.1037/0012-1649.35.4.1132

Iverson, J. M., and Goldin-Meadow, S. 2005. "Gesture paves the way for language development." *Psychological Science* 16: 368–371. DOI: 10.1111/j.0956-7976.2005.01542.x

Jackendoff, R. 2002. *Foundations of Language: Brain, Meaning, Grammar, Evolution*. Oxford: Oxford University Press.

Jancovic, M. A., Devoe, S., and Wiener, M. 1975. "Age-related changes in hand and arm movements as nonverbal communication: Some conceptualizations and an empirical exploration." *Child Development* 46: 922–928. DOI: 10.2307/1128398

Kegl, J., Senghas, A., and Coppola, M. 1999. "Creation through contact: Sign language emergence and sign language change in Nicaragua." In *Language Creation and Language Change: Creolization, Diachrony, and Development*, M. DeGraff (ed.), 179–237. Cambridge, MA: MIT.

Kendon, A. 1980. "Gesticulation and speech: Two aspects of the process of utterance." In *The Relationship of Verbal and Nonverbal Communication*, M. R. Key (ed.), 207–227. The Hague: Mouton & Co.

Kendon, A. 1998. *Sign Languages of Aboriginal Australia: Cultural, Semiotic and Communicative Perspectives*. Cambridge: Cambridge University Press.

Kendon, A. 2004. *Gesture: Visible Action as Utterance*. Cambridge: Cambridge University Press.

Langus, A., and Nespor, M. 2010. "Cognitive systems struggling for word order." *Cognitive Psychology* 60: 291–318. DOI: 10.1016/j.cogpsych.2010.01.004

Mathur, G., and Rathmann, C. 2010. "Verb agreement in sign language." In *Sign Languages: A Cambridge Language Survey*, D. Brentari (ed.), 173–196. Cambridge: Cambridge University Press. DOI: 10.1017/CBO9780511712203.010

McNeill, D. 1992. *Hand and Mind: What Gestures Reveal About Thought*. Chicago: University of Chicago Press.

Meir, I., Lifshitz, A., Ilkbasaran, D., and Padden, C. 2010. "The interaction of animacy and word order in human languages: A study of strategies in a novel communication task." In *Proceedings of the Eighth Evolution of Language Conference*, A. D. M. Smith, M. Schouwstra, B. de Boer and K. Smith (eds), 455–456. Singapore: World Scientific Publishing Co. DOI: 10.1142/9789814295222_0090

Morford, J. P., and Goldin-Meadow, S. 1997. "From here to there and now to then: The development of displaced reference in homesign and English." *Child Development* 68: 420–435. DOI: 10.2307/1131669

Newmeyer, F. J. 2000. "On the reconstruction of 'proto-world' word order." In *The Evolutionary Emergence of Language*, C. Knight, M. Studdert-Kennedy and J. R. Hurford (eds), 372–388. New York: Cambridge University Press. DOI: 10.1017/CBO9780511606441.022

Novack, M., Congdon, E., Hermani, N., and Goldin-Meadow, S. 2014. "From Action to Abstraction: Using the Hands to Learn Math". *Psychological Science* 25: 903–910 DOI: 10.1177/0956797613518351

Ozyurek, A., Furman, R., and Goldin-Meadow, S. 2014. On the way to language: Emergence of segmentation and sequencing in motion event representations without a language model. *Journal of Child Language.* In press.

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

Perry, M., Church, R. B., and Goldin-Meadow, S. 1988. "Transitional knowledge in the acquisition of concepts." *Cognitive Development* 3: 359–400. DOI: 10.1016/0885-2014(88)90021-4

Phillips, S. B., Goldin-Meadow, S., and Miller, P. J. 2001. "Enacting stories, seeing worlds: Similarities and differences in the cross-cultural narrative development of linguistically isolated deaf children." *Human Development* 44: 311–336. DOI: 10.1159/000046153

Pine, K. J., Lufkin, N., and Messer, D. 2004. "More gestures than answers: Children learning about balance." *Developmental Psychology* 40: 1059–106. DOI: 10.1037/0012-1649.40.6.1059

Sandler W., Meir, I., Padden, C., and Aronoff, M. 2005. "The emergence of grammar: Systematic structure in a new language." *Proceedings of the National Academy of Science* 102: 2661–2665. DOI: 10.1073/pnas.0405448102

Senghas, A. 2003. "Intergenerational influence and ontogenetic development in the emergence of spatial grammar in Nicaraguan Sign Language." *Cognitive Development* 18: 511–531. DOI: 10.1016/j.cogdev.2003.09.006

Senghas, A., and Coppola, M. 2001. "Children creating language: How Nicaraguan Sign Language acquired a spatial grammar." *Psychological Science* 12: 323–328. DOI: 10.1111/1467-9280.00359

Senghas, A., Kita, S., and Ozyurek, A. 2004. "Children creating core properties of language: Evidence from an emerging Sign Language in Nicaragua." *Science* 305: 1779–1782. DOI: 10.1126/science.1100199

Senghas, A., Ozyurek, A., and Goldin-Meadow, S. 2010. "The evolution of segmentation and sequencing: Evidence from homesign and Nicaraguan Sign Language." In *Proceedings of the Eighth Evolution of Language Conference*, A. D. M. Smith, M. Schouwstra, B. de Boer and K. Smith (eds), 279–289. Singapore: World Scientific Publishing Co. DOI: 10.1142/9789814295222_0036

Singleton, J. L., Morford, J. P. and Goldin-Meadow, S. 1993. "Once is not enough: Standards of well-formedness in manual communication created over three different timespans." *Language* 69: 683–715. DOI: 10.2307/416883

So, C., Coppola, M., Licciardello, V., and Goldin-Meadow, S. 2005. "The seeds of spatial grammar in the manual modality." *Cognitive Science* 29: 1029–1043. DOI: 10.1207/s15516709cog0000_38

Supalla, T. 1982. *Structure and Acquisition of Verbs of Motion and Location in American Sign Language*. Ph.D. dissertation, University of California at San Diego.

Wundt, W. 1973. *The Language of Gestures*. The Hague: Mouton (originally published 1900). DOI: 10.1515/9783110808285