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Forging a morphological system out of two dimensions: Agentivity and number

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Abstract

Languages have diverse strategies for marking agentivity and number. These strategies are negotiated to create combinatorial systems. We consider the emergence of these strategies by studying features of movement in a young sign language in Nicaragua (NSL). We compare two age cohorts of Nicaraguan signers (NSL1 and NSL2), adult homesigners in Nicaragua (deaf individuals creating a gestural system without linguistic input), signers of American and Italian Sign Languages (ASL and LIS), and hearing individuals asked to gesture silently. We find that all groups use movement axis and repetition to encode agentivity and number, suggesting that these properties are grounded in action experiences common to all participants. We find another feature – unpunctuated repetition – in the sign systems (ASL, LIS, NSL, Homesign) but not in silent gesture. Homesigners and NSL1 signers use the unpunctuated form, but limit its use to No-Agent contexts; NSL2 signers use the form across No-Agent and Agent contexts. A single individual can thus construct a marker for number without benefit of a linguistic community (homesign), but generalizing this form across agentive conditions requires an additional step. This step does not appear to be achieved when a linguistic community is first formed (NSL1), but requires transmission across generations of learners (NSL2).

Keywords

Sign language; Language emergence; Morphology; Homesign; Nicaraguan Sign Language; American Sign Language; Italian Sign Language; Gesture; Movement Axis

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1 Introduction

All known spoken languages have a long history of use, as well as contact with other spoken languages, but there are many examples of sign languages that emerge from young or new communities of deaf individuals around the world (Zeshan & de Vos 2012). These new sign languages are not related to previously existing sign languages, and are insulated from the surrounding spoken language because their primary users are unable to hear it (notable exceptions include village and rural sign systems in which hearing members of the community frequently use the manual sign system alongside members of the community who are deaf; see de Vos 2012, Nyst 2012, Sandler, Meir, Padden, & Aronoff 2005). Here we study the emergence of Nicaraguan Sign Language (NSL), a language that has developed within Nicaragua's deaf community over the last forty years (Kegl & Iwata 1989, Kegl, Senghas & Coppola 1999, Senghas & Coppola 2001). We focus, in particular, on how NSL marks two important dimensions: agentivity and number.

Natural languages have strategies for marking agentivity (Mithun 1991, Pustejovsky 1991) and number (Corbett 2000) that surface in the syntax, lexicon and morphology, but these features are not realized uniformly across languages. We suspect that the intersection of these two dimensions could create pressure for greater economy in young and emerging sign languages through combinatorial, morphological structures. This economy might come at the expense of precision and specificity: in the service of facilitating realization of multiple characteristics of an event (agentivity and number), sign productions may end up being less veridical than a more mimetic gestural representation of the event. Our question is whether different amounts of experience with the manual modality as a primary means of communication affects the economy of a morphological system. We are able to test this hypothesis by comparing productions from participant groups with variable experience using the manual modality to communicate, including hearing individuals – who have no experience communicating exclusively in the manual modality – to deaf native signers – who learned an established sign language from birth and continue using this language daily.

Because representation in the manual modality is grounded in action, manual communication systems can exploit iconic or mimetic strategies to encode dimensions like agentivity and number, and these iconic affordances could lead to distinct trajectories for marking these two dimensions. Agentivity involves the presence of a human agent, and the manual modality offers a transparent strategy for encoding this notion—the projection of the agent onto the signer's own body (Meir et al 2010). This mapping can be realized by varying the axis of the movement's trajectory, either relative to the body (towards or away from the body, midsagittal) or independent of the body (in the space in front of the body, lateral). This division of space, between an axis that references the body and one that does not, is not associated with efficiency costs: it is equally economic to use the midsagittal axis of movement relative to the body as it is to use the lateral axis of movement independent of the body.

In contrast, for number, there is an asymmetry in the efficiency of movement strategies available for encoding single versus multiple events. The mapping can be realized by producing one movement for single events, and multiple iterations of the single movement

for multiple events. However, this strategy not only becomes cumbersome with increasing quantities, but it also fails to establish a distinction between one object and sets of more than one object, common to many natural languages (Corbett 2000). The participants in our study who use the manual modality as their primary means of communication do, in fact, demonstrate a more economic marker of number, which we call “unpunctuated repetition” (Coppola et al., 2013). This form is absent in the productions of participants with limited experience using the manual modality. Moreover, the form has a different distribution in groups who have experience using the manual modality, but were not recipients of a sign language as children, and groups who learned their language from other signers. Thus, it seems that both experience and transmission of a language affect the realization of a movement strategy for marking number.

NSL has its origins in schools for special education that were established in Nicaragua’s capital city, Managua, in the 1970s. Deaf children who entered these schools at that time interacted with other deaf children for the first time, in unprecedented numbers (Polich 2005). Though sign language was not used by educators at the schools, an initial cohort of fifty deaf students began converging on a gestural system of communication together, and transmitted that system over the following decade to incoming students as the enrollment expanded. NSL is thus a very young, natural language, less than forty years old, unrelated to other sign languages, with a growing community of approximately 1500 deaf users. Because this language is so young, we can characterize the stages of its development by observing the systems used by deaf individuals who entered the school in Managua at different time points in its emergence. The participants in our study were divided into age cohorts based on the year that they entered the school (Senghas 2003). Individuals who entered prior to 1984 are members of Cohort 1, and individuals who entered between 1984 and 1990 are members of Cohort 2.

We also document the systems of adult homesigners who live in Nicaragua. Homesign systems are created by individuals whose deafness has prevented them from acquiring the spoken language around them, and who have no access to other deaf individuals or an established sign language (Goldin-Meadow 2003). These individuals, lacking a language model, nonetheless develop gesture systems that share many of the features of natural languages, including morphological structure (Goldin-Meadow, Mylander & Butcher 1995; Goldin-Meadow, Mylander & Franklin 2007), syntactic structure (Goldin-Meadow and Mylander 1984, 1998), the grammatical category *subject* (Coppola & Newport 2005), modulators for negation and questions (Franklin, Giannakidou, & Goldin-Meadow 2001), number marking (Coppola, Spaepen, & Goldin-Meadow 2013) and strategies for distinguishing between nominals and predicates (Goldin-Meadow 2003; Coppola & Brentari 2014; Goldin-Meadow, Butcher, Mylander, & Dodge 1994; Goldin-Meadow, Brentari, Coppola, Horton, & Senghas 2015).

Our study explores languages in the manual modality not only because this is where we find young and emerging linguistic systems, but also because we have comparative examples of established sign languages that have existed for many generations, in our case, American Sign Language (ASL) and Italian Sign Language (LIS). In addition, because it is relatively easy for hearing individuals who know no sign language to use their hands without speech in

communicative situations, we can also compare these emerging linguistic systems to the "silent gestures" that hearing individuals produce when asked to describe scenes using only their hands (e.g., Goldin-Meadow, McNeill & Singleton 1996; Gershkoff-Stowe & Goldin-Meadow 2002; Goldin-Meadow, So, Ozyurek & Mylander 2009).

We focus here on expressions of motion and location events in what have come to be known within the sign language literature as "classifier constructions" or "polycomponential verbs." In these constructions, the parameters of handshape, movement, location (place of articulation), and orientation are used discretely and productively to convey meaning (Supalla 1982; Kegl 1990; Janis 1992; Benedicto & Brentari 2004). Recent experimental work has found that handshape in these classifier constructions is categorically produced and perceived (although there is evidence that location is not processed categorically, Emmorey & Herzig 2003), and that these handshapes encode argument structure (Benedicto & Brentari 2004). This study concentrates on classifier constructions because, beyond established sign languages, there is evidence that homesign systems also treat handshape categorically (Goldin-Meadow et al 1995, 2007) and that these classifier handshapes display phonological patterns not found in the gestures hearing individuals produce when asked to gesture silently on a similar task (Brentari, Coppola, Mazzoni & Goldin-Meadow 2012; see also Goldin-Meadow 2015).

In this study, we turn to movement, which is understudied relative to handshape, but has been acknowledged as a fundamental parameter in sign language grammars since Stokoe's (1960) first linguistic model of American Sign Language. We analyze features of movement in descriptions of short events that involve an arrangement or placement of object(s). We concentrate specifically on classifier expressions of movement and location. We focus on classifier constructions and not other verbal constructions because homesigners and silent gesturers have been found to produce classifier-like gestures (e.g., Goldin-Meadow et al 1995, 2007, Brentari et al. 2012), allowing us to draw comparisons between sign language forms and these gestures. We ask whether participants use features of movement to encode characteristics of events from stimuli clips (henceforth "vignettes"). The events depicted in these vignettes contrast in two dimensions: agentivity (agent vs. no-agent) and number (one vs. many objects). Vignettes were of four types: single with no agent (e.g., a lollipop is located on a table); single with an agent (e.g., a hand places a lollipop on a table); multiple with no agent (e.g., a number of lollipops are located on a table), and multiple with an agent (e.g., a hand places a number of lollipops on a table). We ask, first, whether participants use features of movement systematically to indicate whether a human agent is present or absent in the event (agentivity) and whether the event involves one or many objects (number). We then ask how these strategies are combined to jointly mark agentivity and number. By independently varying two dimensions—agentivity and number—we strive to capture the natural sequence of steps that a sign system undergoes as it develops mechanisms for encoding two simultaneously varying dimensions.

2 Methods

2.1 Participants

The study includes three participant groups from Nicaragua: adult homesigners, members of the first cohort of NSL, and members of the second cohort of NSL. In addition, we collect data from native signers of two sign languages with long histories of continuous use, ASL and LIS, and from hearing individuals in the same communities who are native speakers of English or Italian.

Four adult deaf homesigners participated in the study (1 female, 3 male; mean age 24 years, age range 20–29). They do not know each other, nor are they part of the deaf community in Managua that uses NSL; each of their systems is individual and idiosyncratic (Coppola & Newport, 2005; Goldin-Meadow et al., 2015). They have not attended school regularly, have little or no knowledge of written or spoken Spanish, and rely exclusively on their homesign system to communicate with hearing friends and family.

The two groups of NSL signers who participated in the study are distinguished by their date of entry into the school, as described earlier. The four participants who are members of the first cohort of NSL entered the school before 1983 (2 females, 2 males; mean age 37.5 years, range 33–43 years). These participants were presumably homesigners before attending the school. Once they started to interact with other deaf individuals, however, their systems changed as they began to converge on the new language that would become NSL (Senghas 2003). These participants now use NSL daily, as their primary language, to interact with the growing deaf community in Managua. The organization of their systems is one way to understand the impact of having a social community of users on the structure of a linguistic system.

The four participants who are members of the second cohort of NSL entered the school in Managua between 1984 and 1990 (2 females, 2 males; mean age 21.1 years, range 19–22 years). These participants are also likely to have entered the school with homesign systems, but then were exposed to the system developed by the first cohort at school.

These participants are thus the first group who gained not just a shared community of users when they started school, but also a language model accessible to them in the manual modality. All of the NSL participants entered the signing community before age 6 (mean age of entry 4.0 years, range 2.1–5.7 years).

The two groups of deaf signers come from the United States and Italy. The participants from the United States are native signers of ASL from the greater Chicago area (4 female; mean age 45.5, range 33–62) and the participants from Italy are native signers of LIS from the greater Milan metropolitan area (1 female, 3 male; mean age 35.6, range 30–39). All learned sign language from birth and continue to use ASL or LIS as their primary language in their daily lives.

In addition to the eight native signers, eight hearing individuals (4 native English speakers and 4 native Italian speakers) participated in the study. The native English speakers were students at the University of Chicago (4 female; mean age 22.8, range 21–24) and the native

Italian speakers were students at the Università di Firenze (2 female and 2 male; mean age 23.7, range 20–26).

2.2 Stimuli and Procedures

Photographs and short video clips, "vignettes," were used as an elicitation tool for this study because they are easy to describe and accessible as stimuli to all of the participants in our study. Participants were shown vignettes depicting eleven manipulable objects: toy planes, books, pens, lollipops, tweezers, televisions, cigars, marbles, coins, strings and pieces of tape. We analyzed movement for a subset of the objects—planes, books, lollipops and pens, all of which have been shown previously to elicit handshape contrasts in the native signers of ASL and LIS, the NSL signers in cohorts 1 and 2, and the Nicaraguan homesigners who participated in our study (Brentari, Coppola, Mazzoni & Goldin-Meadow 2012, Goldin-Meadow et al. 2015). Each object was presented in 8 conditions[1]: 4 Agent conditions, two in which a hand placed one object (Single) on a table (one in a canonical position, and one in an unusual position), and two in which a hand placed many objects (Plural) on a table (one with the objects in a neat row, and one with the objects in disarray); and 4 No-agent conditions, two in which one object (Single) is located on a table (one in a canonical position, and one in an unusual position), and two in which many objects (Plural) are located on a table (one with the objects in a neat row, and one with the objects in disarray). An example of the lollipop vignettes, with the objects in canonical position, is presented in Figure 1. This set of vignettes is intended to elicit a paradigm of forms where the distribution of the two target structures can be observed, similar to eliciting a verbal paradigm in a spoken language.

Instructions were presented in the participant's language. The hearing participants (native speakers of English and Italian) were instructed in their native language to "describe what you see without using your voice," a condition we call *silent gesture* (Singleton et al 1993, Goldin-Meadow et al 1996, Ozyurek, Furman & Goldin-Meadow 2015). Signers of ASL or LIS were instructed to describe what they saw in their native languages to an experimenter (with one exception, the experimenter was a native signer of the language under investigation). Signers of NSL received similar instructions and described the conditions to another fluent signer of NSL. For the Nicaraguan homesigners, the experimenter indicated the computer screen with a shrug and inquisitive look. All homesign participants understood this gesture to mean that they should describe the scene using their homesign system. They completed the task addressing their most familiar communication partner.

Participants' responses were videotaped and clipped into an individual file for each trial. Trials were transcribed and coded using ELAN (Crasborn & Sloetjes 2008; ELAN), a tool developed for multimodal language analysis at the Max Planck Institute for Psycholinguistics in Nijmegen, The Netherlands.

[1]In addition to these 8 vignettes, each object was presented in two other vignettes, in a typical activity (e.g., eating a lollipop) and falling (e.g. a lollipop falling); the motion data from these vignettes are not analyzed here because the activities do not involve either locating or placing an object.

2.3 Coding

Responses from ASL, LIS, and NSL signers typically consisted of two parts: a label or lexical item that identified the object in the vignette (the nominal element in the sentence), and a description of what happened in the vignette (the predicate in the sentence); the event description was typically a classifier predicate. Two of the participant groups, the silent gesturers and the homesigners, lacked a standard lexicon and conventional grammar. To conduct a comparable analysis across all participant groups, we followed Brentari et al. (2013) and Goldin-Meadow et al. (2015) and isolated the portion of each response that identified or represented the object, typically produced on the body or in neutral space, and coded it as the Label. We then isolated the part of the response that represented the activity in the vignette and coded it as the Event Description. In this study, we are interested in the movement features in classifier predicates; we therefore looked only at the portions of responses identified as Event Descriptions. For all groups, a primary and secondary coder transcribed subsets of the data to establish reliability. One pair of coders focused on the data from homesigners, a second pair of coders coded the data from American and Italian participants (silent gesturers and ASL and LIS signers) and a third pair of coders coded data from the first and second cohorts of NSL. The pairs also coded subsets of the data from other pairs. The three pairs of coders agreed on an average of 80% of decisions classifying gestures/signs as Labels or Events.

2.3.1 Movement Axis—The movement in each Event was coded for the following features: axis, repetition, and duration. The axis of movement was coded as either midsagittal or lateral. If the hand moved relative to the participant's body, either away from the body or towards the body, the movement was coded as *midsagittal* (see Brentari, 1998, for discussion of midsagittal plane, and Pfau & Steinbach 2006, for illustrations of midsagittal and lateral movements in German Sign Language). Movements that were produced in front of the participant's body could be vertical or horizontal and were coded as *lateral*; the hand's position relative to the body did not change during lateral movements. If a response contained at least one midsagittal movement, the axis of the response is classified as midsagittal; however, we noted whether the response also contained a lateral movement. Figure 2 presents examples of each movement axis in an ASL signer. Inter-coder reliability was 93% for coding axis of movement.

2.3.2 Movement Repetition—Responses were coded as containing a single movement (one movement path) or movements with repetition (multiple movement paths separated by a transitional movement). A movement path began when the handshape was fully formed and tense, and ended either when the direction of movement changed or the handshape changed or relaxed. If a movement path was duplicated, without a change in handshape or pause, it was coded as having repetition. However, if a gesture or sign intervened between the duplicated movement paths, the response was coded as a series of single movement responses.

We identified two types of movements with repetition: *punctuated* and *unpunctuated*. A repetition was coded as Punctuated when the full path of the movement was repeated for each iteration, and the hand returned to approximately the same initial position for each

path. A repetition was coded as Unpunctuated when the full path of the first iterated movement was not fully repeated in subsequent iterations but was significantly abbreviated, without the hand returning to the initial starting position each time; the repeated movements were thus not separated by punctuated breaks (Coppola, Spaepen, & Goldin-Meadow 2013). Single movements and the two types of movements with repetition are illustrated in Figure 3 for both the lateral and midsagittal axes (note that unpunctuated repetition does not occur in the midsagittal axis). Inter-coder reliability was 87% for coding type of repetition.

2.3.3 Movement Duration—We coded the duration (in msec) of movement paths and holds for single movements, punctuated repeated movements, and unpunctuated repeated movements.

3 Results

All participants (N=28) provided a response to each of the 32 vignettes analyzed for this study (8 per object), but some responses did not contain a relevant Event Description. As noted earlier, we consider here only responses with relevant Event Descriptions. We calculated the proportion of responses containing a relevant event description for each individual in a group to generate a mean number of responses included in these analyses per group. Responses with an Event Description accounted for a mean of .95 of each individual's total number of responses for the 4 American Silent Gesturers and 4 Italian Silent Gesturers (225 responses in total), a mean of .95 of responses from the 4 Homesigners (122 responses in total), a mean of .86 of responses from the 4 NSL Cohort 1 signers (110 responses total), a mean of .98 of all responses for the 4 NSL Cohort 2 signers (121 responses in total), and a mean of .99 of all responses for the 4 ASL and 4 LIS signers (245 responses in total).

3.1 Movement Marking Agentivity: Movement Axis

We first ask whether participants use features of movement to consistently encode information about the agentive status of an event. Our initial prediction regarding movement axis was that the midsagittal axis would be used more often in descriptions of Agent vignettes because it references the participant's body—as either starting or endpoint of the movement—and provides a relatively transparent strategy for indicating the presence of a human agent acting on an object. We therefore compared the movements produced by all participant groups for Agent vs. No-agent vignettes (collapsing across Single and Plural) using two measures: (1) Movement axis and (2) Movement repetition. We did not expect movement repetition to vary systematically with the agentivity of the vignettes.

Figure 4 presents the proportion of movement types produced by each of the five groups (the data for the ASL and LIS signers are combined, as are the data for the American and Italian silent gesturers). The proportion of movements with a midsagittal or lateral axis typically summed to 1.00, as did the proportions of single or plural movements, so only the proportions of midsagittal axis movements and movements with repetition in Agent and No-Agent conditions are presented below. The proportion of responses with midsagittal axis movements in Agent and No-Agent vignettes appear in the left graph. The proportion of

responses with movements containing repetition in Agent and No-Agent vignettes appear in the right graph.

We conducted a repeated measures ANOVA with one within-subjects factor, *vignette agentive type* (agent, no agent), and one between-subjects factor, *group* (silent gesture, homesign, NSL cohort 1, NSL cohort 2, ASL & LIS), and with the proportion of *responses with a midsagittal axis* as the dependent factor. We found a main effect of vignette agentive type, $F(1, 27) = 126.05$, $p < .0001$, indicating that participants were more likely to use a movement with a midsagittal axis in responses to vignettes with an agent than vignettes without an agent. There was no effect of group $F(1,27) = .99$, $p=.428$, indicating that all five groups displayed this pattern.

We conducted a comparable analysis on the repetition measure, with one within-subjects factor, *vignette agentive type* (agent, no agent), and one between-subjects factor, *group* (silent gesture, homesign, NSL cohort 1, NSL cohort 2, ASL/LIS), and with the proportion of *responses containing movement with repetition* as the dependent factor. Unlike the patterns for movement axis, we found no relationship between the presence or absence of an agent and the distribution of single and repeated movements, $F(1, 27) = 1.08$, $p=.31$. There was also no effect of group $F(1,27) = .34$, $p = .85$, indicating that there was no difference in the movement repetition patterns for Agent vs. No-agent vignettes in any of the five groups (they produced the same proportion of *movements with repetition* on both types of vignettes).

Recall that we considered a response midsagittal if it contained at least one midsagittal movement; some of these midsagittal responses *also* included lateral movements. A response that contains both midsagittal and lateral movements, when used to describe an Agent vignette, in effect, represents both the action of the human agent (putting down the object, the midsagittal movement) and the result of that action (the object being located, the lateral movement). Figure 5 presents the proportion of mid-sagittal responses produced in response to Agent vignettes that did, and did not, also contain a lateral movement. Silent Gesturers produced more responses that contained only midsagittal movements than responses containing both midsagittal and lateral movements, while Homesigners, and NSL Cohort 1 signers produced roughly the same proportion of responses with only a midsagittal movement, compared to responses with both midsagittal and lateral movements. In contrast, NSL Cohort 2 signers and ASL/LIS signers displayed the opposite pattern, producing more responses that contained both types of movements than responses that contained only midsagittal movements. Thus, individuals who acquired their sign language from other signers – the participants who had an accessible language model – preferred to represent not only the human agent's actions in the event (putting down the object), but also the outcome of those actions (the located object).

3.2 Movement Marking Number: Movement Repetition

In the second analysis, we turn to features of movement that could represent number. Research on established sign languages has found relationships between repetition and aspectual modifications (Klima & Bellugi 1979) and telicity (Strickland et al 2015, Malaia et al 2013, Wilbur 2008). Repetition thus appears to be a flexible strategy employed for a

diverse array of grammatical functions in sign languages. We predicted that repeating the movement path would be a transparent way to indicate whether there was one versus many objects involved in an event. Recall that our stimuli were designed to present a clear contrast between *single* events (with either a single static object, or a transitive "putting event" with a single object) and *multiple* events (with an arrangement of multiple static objects, or a transitive "putting event" with multiple objects). We therefore compared the movements produced for Single vs. Multiple vignettes (collapsing across Agent and No-Agent), again using two measures: (1) Movement repetition and, for comparison, (2) Movement axis.

Figure 6 presents the proportion of responses for each of the five groups. Since midsagittal and lateral movements typically sum to 1.00 (as noted earlier), we include the proportion of midsagittal movements only for single trials (orange bars) and plural trials (blue bars). All five groups used approximately the same proportion of midsagittal movements in both single and multiple trials. In the panel on the right, we present the proportion of movements with repetition only (movements with repetition and single movements typically sum to 1.00) for single trials (orange bars) and plural trials (blue bars).

We conducted a repeated measures ANOVA with one within-subjects factor, *vignette plural type* (singular, plural), and one between-subjects factor, *group* (silent gesture, homesign, NSL cohort 1, NSL cohort 2, ASL/ LIS), and with the proportion of *responses with a movement with repetition* as the dependent factor. We found a main effect of vignette plural type, $F(1, 27) = 433.30$, $p < .0001$, indicating that participants were more likely to use a movement with repetition in descriptions of plural vignettes than single vignettes. There was no effect of group, $F(1, 27) = 2.11$, $p = .11$, indicating that all five groups displayed this pattern.

We conducted a comparable analysis on the movement axis measure with one within-subjects factor, *vignette plural type* (single, multiple), and one between-subjects factor, *group* (silent gesture, homesign, NSL cohort 1, NSL cohort 2, ASL/ LIS), and with the proportion of *responses with a midsagit-tal axi*s as the dependent factor. Unlike the patterns for movement repetition, we find no relationship between the single or plural status of the vignette and the distribution of movements with a midsagittal axis, $F(1, 27) = 0.32$, $p=0.58$. There was no effect of group, $F(1, 27) = .10$, $p = .98$, indicating that there was no difference in the movement axis patterns for Single vs. Plural vignettes in any of the five groups (all of the signers produced approximately the same proportion of *midsagittal* movements in Single and Plural vignettes).

Movements with repetition consisted of two types: punctuated repetition and unpunctuated repetition (see examples in Figure 3). Figure 7 presents the proportion of movements with repetition that participants produced in response to the plural vignettes, classified according to punctuated vs. unpunctuated. The striking finding is that Silent Gesturers overwhelmingly represented number using only movements with punctuated repetition, and not movements with unpunctuated repetition; only 3 silent gesturers produced this form, and each produced the unpunctuated form only once. In contrast, all of the signers used at least some movements with unpunctuated repetition. This form is thus used only by individuals for whom the manual modality is a frequent means of communication[2].

3.3 Movement Marking of Number in Relation to Agentivity

There are two types of multiple vignettes in the stimuli, those that contained an agent and those that did not. In the final analysis, we ask whether the participants mark number consistently across these two types of "multiple" conditions, or whether there was a unique form for multiple vignettes with an agent versus multiple vignettes without an agent. We thus compare the distribution of punctuated and unpunctuated movements in No-Agent plural and Agent plural vignettes.

Figure 8 presents the proportion of responses containing *movements with repetition* classified according to the manner of repetition (punctuated vs. unpunctuated) that the five groups produced in response to Multiple vignettes with an agent (right graph) and without an agent (left graph). Since the Silent Gesturers produced no forms with unpunctuated repetition, they (necessarily) used only punctuated repetition for plural events in both No-Agent and Agent vignettes. All of the signers used both punctuated and unpunctuated repetition for Multiple events in No-agent events (left graph). Interestingly, however, Homesigners and NSL Cohort 1 did *not* extend the unpunctuated repetition form to Agent vignettes (right graph)[3]—they used it exclusively in No-Agent vignettes. In contrast, NSL Cohort 2 signers and ASL/LIS signers used unpunctuated repetition for all Multiple vignettes, both No-Agent and Agent. The unpunctuated repetition form thus encodes number independent of agentivity for these two groups of signers, both of whom learned their system from other signers.

In the first analysis, we proposed that the axis of a movement could be used to indicate the presence or absence of an agent, and we found that all groups used midsagittal movements to describe vignettes with an agent, and lateral movements to describe vignettes without an agent. Note, however, that movements with unpunctuated repetition are produced only in the lateral axis (see Figure 3). In Multiple vignettes without an agent, this limitation does not pose a problem—when signers use the unpunctuated plural for a No-Agent vignette, the lateral axis of the form also corresponds to the agentive status of the event (lateral axis is associated with events lacking an agent). However, using the unpunctuated plural in vignettes with an agent sets up a theoretical "competition" between forms. If signers use the unpunctuated plural for an Agent vignette, then the lateral axis of the unpunctuated form is incongruent with the (midsagittal) axis associated with events with an agent.

If signers restrict the contrast between midsagittal and lateral axes to expressing the agentive status of an event, such that the lateral axis is used exclusively in No-Agent trials and the midsagittal axis is used exclusively in Agent trials, then the unpunctuated form should appear *only* in Multiple No-Agent vignettes, where the plural axis is compatible with the agentive axis. This is exactly the pattern we see for Homesig-ners and NSL Cohort 1. In descriptions of Multiple Agent vignettes, they use the punctuated plural form, which can

[2]In Coppola et al 2013, hearing participants did occasionally use the unpunctuated form, but it was never incorporated into a sentence. Additionally, these hearing participants were the primary communication partners of homesign adults, and thus had extended experience using their hands to communicate.

[3]Two homesigners did, on occasion, extend unpunctuated repetition to the Agent vignettes; one used the form twice in Agent Plural vignettes, the other used the form only once.

occur in either the lateral or midsagittal axis. By using the punctuated plural, the axis information continues to accurately represent the agentive status of the event.

If, however, the unpunctuated form encodes *only* number and not agentivity, then we might expect the unpunctuated plural to appear not only in Multiple No-Agent trials (where the axis information in the plural is consistent with the agentive status of the event), but also in Multiple Agent trials (where the axis information about number contradicts the agentive status of the event). This is the pattern for NSL Cohort 2 signers, as well as ASL and LIS signers, who use the unpunctuated plural form in both Multiple No-agent trials and Multiple Agent trials. If these signers are using unpunctuated forms to indicate number alone, they should mark the presence of an agent with an alternative strategy in descriptions of Agent vignettes (e.g., by adding a second form that uses the midsagittal axis). We found that, of the unpunctuated forms that NSL Cohort 2 signers produced in the Agent Plural condition, 63% are accompanied by a second movement in the midsagittal axis. For the ASL/LIS signers, 58% of the unpunctuated forms were accompanied by an additional midsagittal movement. Agentivity is thus encoded by this additional movement. We suspect that the remaining unpunctuated forms (i.e., the unpunctuated forms that are not accompanied by a second movement in the midsagittal axis) will have agentivity marked in some other way, for example, by handshape (i.e., they may produce the unaccompanied unpunctuated movements with a handle handshape, which signals agentivity in both established and emerging sign languages, Brentari et al. 2015, Goldin-Meadow et al 2015). We will explore this possibility in future work.

3.4 Phonetic Correlates of Unpunctuated Movement: Duration

Unpunctuated repetition is a form used by all of the individuals who use the manual modality as their primary communication system, even Homesigners who created their systems without input deaf individuals. As described earlier, movements with punctuated repetition contain full iterations of the original path of the movement, with the hand returning to the same approximate starting position. Movements with punctuated repetition are thus a series of connected single movement signs, which should be longer in duration than a single movement without repetition, and may be some multiple of the duration of single movements. We hypothesize that movements with punctuated repetition are akin to a phrase consisting of a sequence of multiple signs or gestures. It is less obvious whether movements with unpunctuated repetition are more similar to the phrasal unit (movements with punctuated repetition) or to the prosodic word unit (single movements with no repetition). To better understand the status of the unpunctuated form in emerging and established systems, we compare the duration of movements with unpunctuated repetition to the duration of single and punctuated movements. Coppola and colleagues (2013) have argued that the unpunctuated repetition form is a morphological marker for an unspecified number of items (“more than one,” “many”), whereas the punctuated repetition form is a marker for the exact number of items (“four”). We plan to investigate this in future analyses in which we consider the specific number of objects in Multiple trials compared to the precise number of repetitions.

To establish the standard length of a prosodic word, we coded the duration of single movements (in msec) for all four objects in all Single vignettes (N=1,315). We also coded the duration of all of the unpunctuated movements (N=79) and an equivalent number of punctuated movements (N=92) in “Multiple” vignettes. Figure 9 shows the mean duration of each movement type (in msec) for each of the five participant groups.

We conducted an ANOVA to compare mean duration for Single movements, Punctuated movements, and Unpunctuated movements. Silent Gesturers produced too few Unpunctuated movements to analyze statistically. We therefore examined this group separately and conducted a one-way ANOVA with *movement type* (Single movement, Punctuated movement) as the within-subjects factor, and *duration* as the dependent factor. As expected, we found that Punctuated movements were significantly longer than Single movements for Silent Gesturers, $F(2)=252.8$, $p<0.001$.

We analyzed the remaining four groups of signers using a two-way ANOVA, with *movement type* (Single movement, Punctuated movement, Unpunctuated movement) as the within-subjects factor, and *group* (Homesigner, Cohort 1, Cohort 2, ASL/LIS signers) as the between-subjects factor, and with *duration* as the dependent factor. There was a significant effect of movement type on duration, $F(2)= 232.3$, $p<0.001$, and a significant effect of group, $F(3)=21.1$, $p<0.001$, as well as an interaction between movement type and group, $F(6)=10.6$, $p<0.001$. The group effect and interaction is due to the homesigners, who had significantly shorter durations than the other three groups (NSL 1, NSL 2, and ASL/LIS). For all groups, Punctuated movements were significantly longer than Unpunctuated movements (Mean Difference=1033.8, $p<0.001$) and than Single movements (Mean Difference=1289.3, $p<0.001$). Unpunctuated movements were also significantly longer than Single movements (Mean Difference=255.5, $p<0.001$). We thus find that movements with unpunctuated repetition are not as long as movements with punctuated repetition, but they are also not as short as single movements.

4 Discussion

Our study has three central findings. First, all groups used the axis along which movement is produced to represent Agent vs. No-Agent events, and used repetition of movement to represent Multiple events. These strategies for encoding meaning thus appear to be accessible to all users and may grow out of shared experience with action, which informs gestures that are spontaneously produced by silent gesturers and perhaps influenced the initial stage of established sign languages. Second, although silent gesturers used punctuated repetition to mark number (which transparently maps the number of movements in the gesture to the number of objects in the vignette) - they did not use unpunctuated repetition (repeated movements that are not separated by punctuated breaks and that do not transparently map onto the number of objects in the vignette) to mark number. The unpunctuated form was used only by homesigners, NSL signers, and ASL/LIS signers, and thus may reflect the fact that these users have manual linguistic systems that they use in their daily lives. Third, homesigners and NSL cohort 1 signers used unpunctuated repetition only when describing plural events without an agent. In contrast, second cohort NSL signers and ASL/LIS signers, who learned their signs from other users, used unpunctuated repetition

when describing plural events with and without an agent. This finding suggests that full grammaticization of unpunctuated repetition, as a marker restricted to encoding number, emerges only when a communication system is passed through at least one generation of learners.

4.1 Shared Strategies: Action as the root of gestural communication

Movement axis, particularly movement relative to the body, is an accessible strategy that can easily be used to indicate the presence of an agent in an event. As predicted, this strategy was evident even in silent gesturers, who lack experience using the manual modality as their primary means of communication, and in homesigners, who have no access to linguistic input from other deaf individuals. In a study of verbs in three different sign languages, Meir and colleagues (2007) note that visual languages can offer a window onto the structure of languages by allowing insight into properties that cannot be seen in the spoken modality. In our study, this insight is reflected in the way participants signaled the agentive status of an event. All groups used the midsagittal axis—movement to and from the body—to indicate that an event involved a human agent. The midsagittal axis was not used in descriptions of events without agents. This stable form-meaning mapping is likely to have grown out of experiences that all of the participants had interacting with the world. The participants have had experience manipulating objects like the ones in our vignettes, and they seemed to pattern their use of the midsagittal axis after these experiences.

Interestingly, all of the participants also incorporated movement, this time along the lateral axis, into their descriptions of events that had no agent, even though these events involved no movement at all. The participants used movements with a lateral axis, not to represent the movements of the object (since the objects in the no-agent vignettes were stationary), but to represent the fact that the object was located in a place. These lateral movements are the source of the unpunctuated repetition form, used by all four groups of signers but not by the silent gesturers (we discuss this point in more detail below). One possibility is that the source of this lateral axis is an iconic representation of the arrangement of objects in the stimuli. In half of the vignettes, objects were presented in a “canonical” arrangement. For Multiple conditions, this meant that the objects appeared in one or two rows (see figure 1.). In the other half of the vignettes, however, objects were presented in a non-canonical or “strange” arrangement. For Multiple conditions in the “strange” arrangement, this meant that the objects appeared in a random pile on the table. We confirmed that 27% of the unpunctuated forms in the responses were produced in descriptions of a “strange” arrangement, indicating that this movement is *not* strictly a reflection of the arrangement of the objects in the vignette.

All participants also seemed to use their experience as actors as a basis for the repetition strategy recruited to mark plurality. Participants saw a hand place an object or multiple objects on a table in the agent events; to describe these events, they produced a midsagittal movement to indicate placing an object, and they repeated the movement a number of times to indicate placing more than one object. They extended this strategy to no-agent events, producing a lateral movement once to indicate a single object in place, and repeating the movement a number of times to indicate more than one object in place.

4.2 Moving away from action: Toward efficient communication

The punctuated repetition strategy, effective within the limited scope of our task, can easily become cumbersome in daily interactions. The more objects that need to be described, the longer the string of signs needed to describe them. There is little pressure on silent gesturers to make their descriptions efficient—their goal is to create descriptions that are clear and transparent. In contrast, signers, even homesigners, use the manual modality on a daily basis as their sole means of communication and thus might be more susceptible to pressure to communicate efficiently. Indeed, we found that in all five groups, signs with punctuated movements were significantly longer than signs (or gestures) with a single movement. Punctuated repetition thus seems to function like a phrase in terms of duration; that is, like a string of signs signaling many objects.

Unpunctuated repetition is a potential solution to this problem. It allows signers to make a series of quick movements, all within the bounds of a single sign, to signal number. Unpunctuated repetition thus seems to function like a single word in terms of duration—one sign with a plural marker (meaning *more than one*) incorporated into the sign. The fact that unpunctuated repetition was used by all of the signers (and not by silent gesturers) suggests that the form may have been invented in response to the communicative pressure to be efficient that the signers experienced in their daily lives. Although the initial pressure to develop an unpunctuated plural form may have come from the need to represent large numbers of objects, it is important to note that the unpunctuated form is used by adult Nicaraguan homesigners not only to represent large sets of objects, but also to represent sets as small as two (Coppola et al 2013).

Note that unpunctuated repetition ends up being less precise than punctuated repetition in terms of indicating exactly how many objects are present. The push toward greater economy may thus result in a less specific or veridical communication system. However, unpunctuated repetition has been found to take on many of the attributes of plural markers in conventional languages, even in homesigners (Coppola et al., 2013)—homesigners integrate these forms into their sentences, using them as morphological markers on the predicate. Thus, although the system may have become less transparent, it has also become more linguistic.

5 Conclusion

We closely analyzed movement features in the manual communications produced by five groups—silent gesturers who were inventing their gestures on the spot; homesigners who invented their signs and use them on a daily basis to communicate with hearing individuals; NSL cohort 1 signers who also invented their signs but use them to communicate with other deaf individuals who share the system; NSL cohort 2 signers who learned their signs from the first cohort; and ASL/LIS signers who learned their signs from proficient users of the systems. We found that all five of the groups used movement systematically to encode two features of events, agentivity and number. Even the silent gesturers used gestures that were characterized by stable form-content mappings between axis of movement and the agentivity of an event, and between repetition of movement and the number (single or multiple) of an event. These relatively iconic mappings accounted for all of the forms that the silent

gesturers produced. But the signers went further, using a dedicated form to represent number—unpunctuated repetition. This form was less mimetic than the forms developed by silent gesturers, and thus had the effect of decreasing the iconicity of the communication system. Finally, NSL cohort 2 signers and ASL/LIS signers (but not homesigners and NSL cohort 1 signers) began to use unpunctuated repetition as a marker for number, separate from agentivity.

Unpunctuated repetition in movement thus illustrates stages in the emergence of combinatorial units in young sign languages. Homesigners, who routinely use the manual modality to communicate with hearing individuals, can construct a marker for plurality without the benefit of a community that shares their sign system. However, full grammaticization of the marker requires an additional step. Importantly, this step is not achieved when a linguistic community is first formed (that is, in NSL cohort 1), but instead takes place only in signers who have both a community of users *and* a language model from which to learn. The close comparison of descriptions of the same stimulus events across groups that vary in whether they routinely use the manual modality for communication, and in whether they invented or learned their signs, allows us to better understand the steps needed to turn descriptive gestures into a linguistic system.

References

Anderson, Stephen. A-morphous Morphology. New York, NY: Cambridge University Press; 1992.

Aronoff, Mark. Morphology by Itself: Stems and Inflectional Classes. Cambridge, MA: MIT Press; 1994.

Benedicto, Elena; Brentari, Diane. Where did all the arguments go?: Argument-Changing properties of classifiers in ASL. Natural Language and Linguistic Theory. 2004; 22:743–810.

Brentari, Diane. A Prosodic Model of Sign Language Phonology. Cambridge, MA: MIT Press; 1998.

Brentari, Diane; Coppola, Marie; Mazzoni, Laura; Goldin-Meadow, Susan, et al. When does a system become phonological? Handshape production in gesturers, signers, and homesigners. Natural Language and Linguistic Theory. 2012; 30:1–31. [PubMed: 23723534]

Brentari, Diane; Coppola, Marie; Jung, Ashley; Goldin-Meadow, Susan, et al. Acquiring word class distinctions in American Sign Language. Language Learning and Development. 2013; 9:130–150. [PubMed: 23671406]

Brentari, Diane; Coppola, Marie. What sign language creation teaches us about language. Wiley Interdisciplinary Reviews: Cognitive Science. 2013; 4:201–211. [PubMed: 26304196]

Brentari, Diane; Di Renzo, Alessio; Keane, Jonathan; Volterra, Virginia, et al. Cognitive, Cultural and Linguistic Sources of a Handshape Distinction Expressing Agentivity. TopiCS. 2015; 7:95–123. [PubMed: 25529989]

Carrigan, Emily; Coppola, Marie. In: Miyake, N.; Peebles, D.; Cooper, R., et al., editors. Mothers do not drive structure in adult homesign systems: Evidence from comprehension; Proceedings of the 34th Annual Conference of the Cognitive Science Society; Sapporo, Japan: Cognitive Science Society; 2013. p. 1398-1403.

Coppola, Marie; Newport, Elissa. Grammatical Subjects in home sign: Abstract linguistic structure in adult primary gesture systems without linguistic input. Proceedings of the National Academy of Sciences. 2005; 102:19249–19253.

Coppola, Marie; Spaepen, Elizabet; Goldin-Meadow, Susan, et al. Communicating about number without a language model: Number devices in homesign grammar. Cognitive Psychology. 2013; 67:1–25. [PubMed: 23872365]

Coppola, Marie; Brentari, Diane. From iconic handshapes to grammatical constrasts: longitudinal evidence from a child homesigner. Frontiers in Psychology. 2014; 5:1–23. [PubMed: 24474945]

Corbett, Greville. Number. Cambridge, UK ; New York: Cambridge University Press; 2000.

Crasborn, Otto; Sloetjes, Han. Enhanced ELAN functionality for sign language corpora. Proceedings of LREC, Sixth International Conference on Language Resources and Evaluation; 2008.

De Vos, Connie. PhD Thesis. Radboud University Nijmegen; Nijmegen: 2013. Sign-spatiality in Kata Kolok: How a village sign language in Bali inscribes its signing space.

ELAN. EUDICO Linguistic Annotator. Available online at: http://tla.mpi.nl/tools/tla-tools/elan/

Emmorey, Karen; Herzig, Melissa. Perspectives on classifier constructions in sign language. Mahwah, N.J: Lawrence Erlbaum Associates; 2003.

Gershkoff-Stowe, Lisa; Goldin-Meadow, Susan. Is there a natural order for expressing semantic relations? Cognitive Psychology. 2002; 45:375–412. [PubMed: 12480479]

Goldin-Meadow, Susan. The resilience of language: What gesture creation in deaf children can tell us about how all children learn language. In: Werker, J.; Wellman, H., et al., editors. Essays in Developmental Psychology series. New York: Psychology Press; 2003.

Goldin-Meadow, Susan. The impact of time on predicate forms in the manual modality: Signers, homesigners, and silent gesturers. TopICS. 2015; 7(2015):169–184.10.1111/tops.12119 [PubMed: 25329421]

Goldin-Meadow, Susan; Mylander, Carolyn. Gestural communication in deaf children: the effects and noneffects of parental input on early language development. Monographs of the Society for Research in Child Development. 1984; 49:1–151. [PubMed: 6537463]

Goldin-Meadow, Susan; Butcher, Cynthia; Mylander, Carolyn; Dodge, Mark, et al. Nouns and Verbs in a Self-Styled Gesture System: What's in a Name? Cognitive Psychology. 1994; 27:259–319. [PubMed: 7828423]

Goldin-Meadow, Susan; Mylander, Carolyn; Butcher, Cynthia, et al. The resilience of combinatorial structure at the word level: Morphology in self-styled gesture systems. Cognition. 1995; 56:195–262. [PubMed: 7554795]

Goldin-Meadow, Susan; McNeill, David; Singleton, Jenny, et al. Silence is liberating: Removing the handcuffs, on grammatical expression in the manual modality. Psychological Review. 1996; 103:34–55. [PubMed: 8650298]

Goldin-Meadow, Susan; Mylander, Carolyn. Spontaneous sign systems created by deaf children in two cultures. Nature. 1998; 391:279–281. [PubMed: 9440690]

Goldin-Meadow, Susan; Mylander, Carolyn; Franklin, Amy, et al. How children make language out of gesture: Morphological structure in gesture systems developed by American and Chinese deaf children. Cognitive Psychology. 2007; 55:87–135. [PubMed: 17070512]

Goldin-Meadow, Susan; Ozyurek, Asli; Sancar, B.; Mylander, Carolyn, et al. Making language around the globe: A cross-linguistic study of homesign in the United States, China, and Turkey. In: Guo, J.; Lieven, E.; Budwig, N.; Ervin-Tripp, S., et al., editors. Crosslinguistic approaches to the psychology of language: Research in the tradition of Dan Isaac Slobin. New York, NY: Taylor & Francis; 2009. p. 27-39.

Goldin-Meadow, Susan; Brentari, Diane; Coppola, Marie; Horton, Laura; Senghas, Ann, et al. Watching language grow in the manual modality: Nominals, predicates and handshapes. Cognition. 2015; 136:381–395. [PubMed: 25546342]

Janis, Wynne. PhD thesis. Buffalo, New York: State University of New York, USA; 1992. Morphosyntax of the ASL verb phrase.

Kegl, Judy. Predicate argument structure and verb-class organization in the ASL lexicon. In: Lucas, C., editor. Sign language research: Theoretical issues. Washington, DC: Gallaudet University Press; 1990. p. 149-175.

Kegl, Judy; Iwata, Gail. Lenguaje de Signos Nicaraguense: A pidgin sheds light on the "creole"? ASL. Proceedings of the Fourth Annual Meeting of the Pacific Linguistics Conference; Eugene: University of Oregon; 1989.

Kegl, Judy; Senghas, Ann; Coppola, Marie, et al. Creation through contact: Sign language emergence and sign language change in Nicaragua. In: DeGraff, M., editor. Language creation and language change: Creolization diachrony, and development. Cambridge, MA: MIT Press; 1999. p. 179-237.

Malaia E, Wilbur RB, Milković M. Kinematic Parameters of Signed Verbs. Journal Of Speech, Language & Hearing Research. 2013; 56(5):1677–1688.

Matthews, Peter. Morphology (Cambridge Textbooks in Linguistics). 2. New York: Cambridge University; 1991.

Meir, Irit; Sandler, Wendy; Padden, Carol; Aronoff, Mark, et al. Emerging Sign Languages. In: Marschark, M.; Spencer, P., editors. Oxford Handbook of Deaf Studies, Language, and Education. Vol. 2. Oxford: Oxford University Press; 2010.

Mithun, Marianne. Active/ agentive case marking and its motivations. Language. 1991; 67:510–546.

Nyst, Victoria. Sign Language Varieties in West Africa. In: Brentari, D., editor. Sign Languages: A Cambridge language survey. Cambridge: Cambridge University Press; 2010. p. 405-432.

Ozyurek, Asli; Furman, Reyhan; Goldin-Meadow, Susan, et al. On the way to language: Event segmentation in homesign and gesture. Journal of Child Language. 2015; 42:64–94. [PubMed: 24650738]

Padden, Carol; Meir, Irit; Aronoff, Mark; Sandler, Wendy, et al. The grammar of space in two new sign languages. In: Brentari, D., editor. Sign Languages: A Cambridge Language Survey. New York: Cambridge University Press; 2010.

Pustejovsky, James. The syntax of event structure. Cognition. 1991; 41:47–81. [PubMed: 1790655]

Polich, Laura. The emergence of the deaf community in Nicaragua: “With sign langauge you can learn so much”. Washington, DC: Gallaudet University Press; 2005.

Pfau, Roland; Steinbach, Marcus. Pluralization in sign and in speech: A cross-modal typological study. Linguistic Typology. 2006; 10:49–135.

Sandler, Wendy; Meir, Irit; Padden, Carol; Aronoff, Mark, et al. The emergence of grammar in a new sign language. Proceedings of the National Academy of Sciences. 2005; 102:2661–2665.

Senghas, Ann. Intergenerational influence and ontogenetic development in the emergence of spatial grammar in Nicaraguan Sign Language. Cognitive Development. 2003; 18:511–531.

Senghas, Ann; Coppola, Marie. Children creating language: How Nicaraguan Sign Language acquired a spatial grammar. Psychological Science. 2001; 12:323–328. [PubMed: 11476100]

Singleton, Jenny; Newport, Elissa. When learners surpass their models: The acquisition of American Sign Language from inconsistent input. Cognitive Psychology. 2004; 49:370–407. [PubMed: 15342259]

Singleton, Jenny; Morford, Jill; Goldin-Meadow, Susan, et al. Once is not enough: Standards of well-formedness in manual communication created over three different timespans. Language. 1993; 69:683–715.

Stokoe, William. Studies in linguistics. Occasional papers; 8. Buffalo: Dept. of Anthropology and Linguistics, University of Buffalo; 1960. Sign Language Structure: an outline of the visual communication systems of the American deaf.

Strickland B, Geraci C, Chemla E, Schlenker P, Kelepir M, Pfau R. Event representations constrain the structure of language: Sign language as a window into universally accessible linguistic biases. Proceedings Of The National Academy Of Sciences Of The United States Of America. 2015; 112(19):5968. [PubMed: 25918419]

Supalla, Ted. PhD Thesis. San Diego, CA: University of California, USA; 1982. Structure and acquisition of verbs of motion and location in American Sign Language.

Wilbur, RB. Complex predicates involving events, time, and aspect: Is this why sign languages look so similar?. In: Quer, J., editor. Signs of the time: Selected papers from TISLR 8. Hamburg, Germany: Signum; 2008. p. 217-250.

Zeshan, Ulrike; de Vos, Connie, editors. Sign Languages in Village Communities: Anthropological and Linguistic Insights. Njimegen: Ishara; 2012.

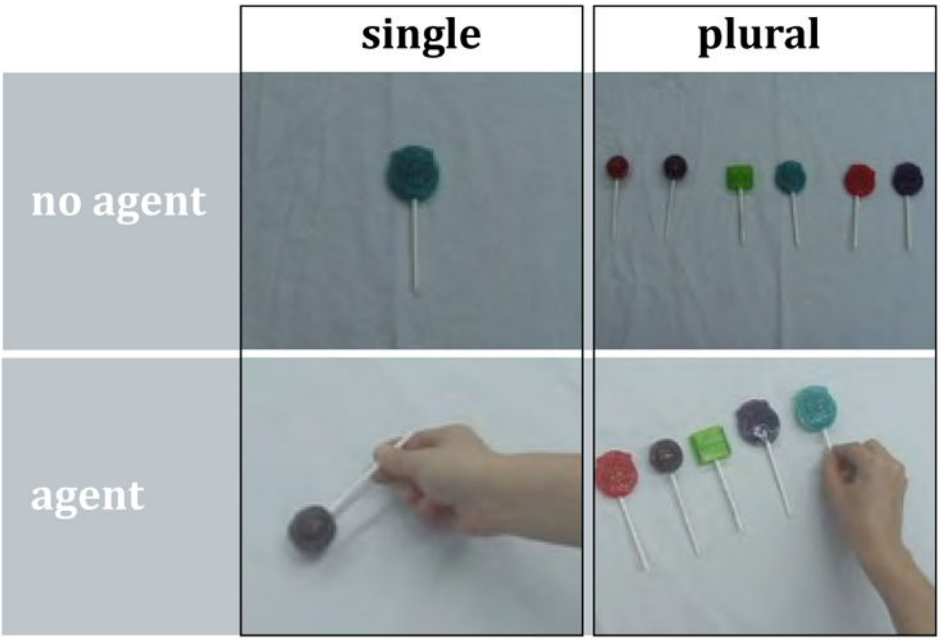

Fig. 1.

Sample stimuli images showing four of eight conditions: single no agent (lollipop alone, upper left image); plural no agent (lollipops in a row, upper right image); single agent (put lollipop alone, lower left image); and plural agent (put lollipops in a row, lower right image).

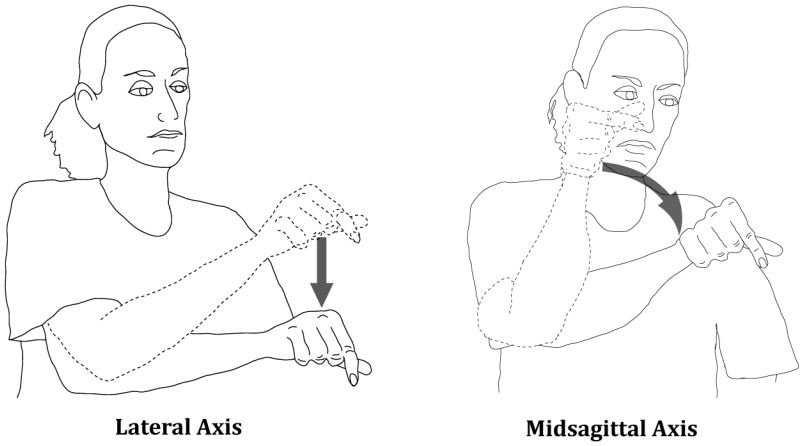

Fig. 2.

Illustration of Lateral movement (Left image), which is horizontal or vertical and occurs in signing space, and Midsagittal movement (Right image), which is movement relative to the body, either towards the body or away from the body.

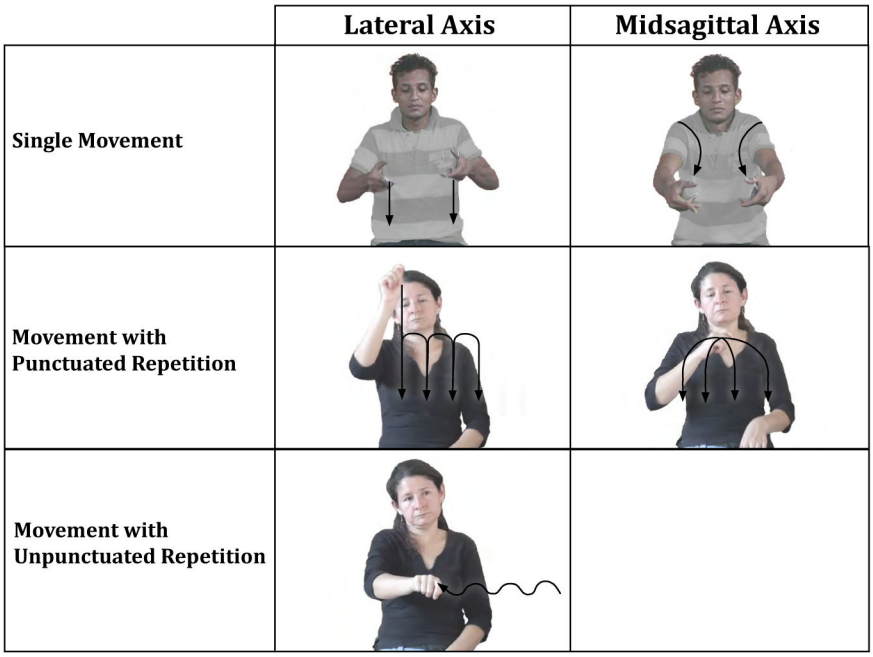

Fig. 3.

Illustration of single and repeated (punctuated and unpunctuated) movements in the Lateral axis (Left column), and single and repeated (punctuated) movements in the Midsaggittal axis (Right column). Note that unpunctuated repetition does not occur in the midsagittal axis.

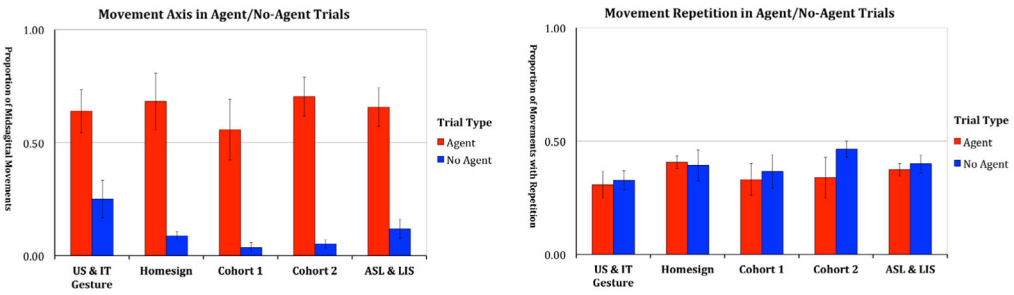

Fig. 4.

The proportion of responses with Midsagittal movement (left graph) and responses with Movements with repetition (right graph) in Agent (red bars) and No-agent vignettes (blue bars) produced by Silent Gesturers, Homesigners, NSL Cohort 1 signers, NSL Cohort 2 signers, and ASL/ LIS signers. Error bars indicate standard errors.

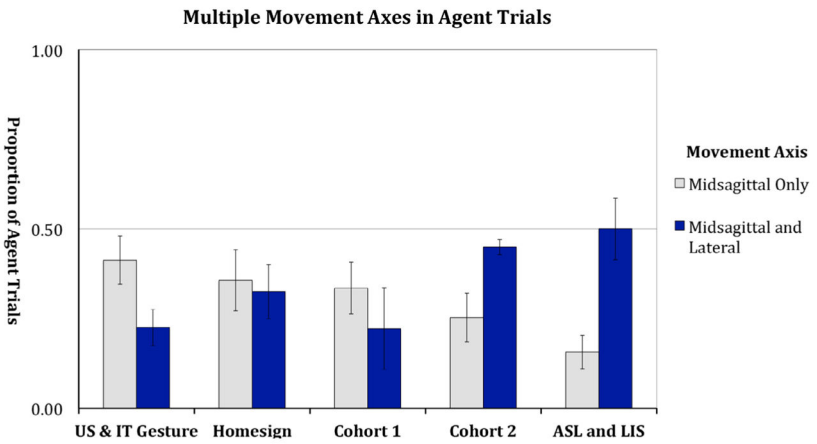

Fig. 5.

The proportion of responses that contained only a midsagittal movement (gray bars) or *both* midsagittal and lateral movements (blue bars) produced by Silent Gesturers, Homesigners, NSL Cohort 1 signers, NSL Cohort 2 signers, and signers of ASL and LIS in descriptions of Agent vignettes. Error bars indicate standard errors.

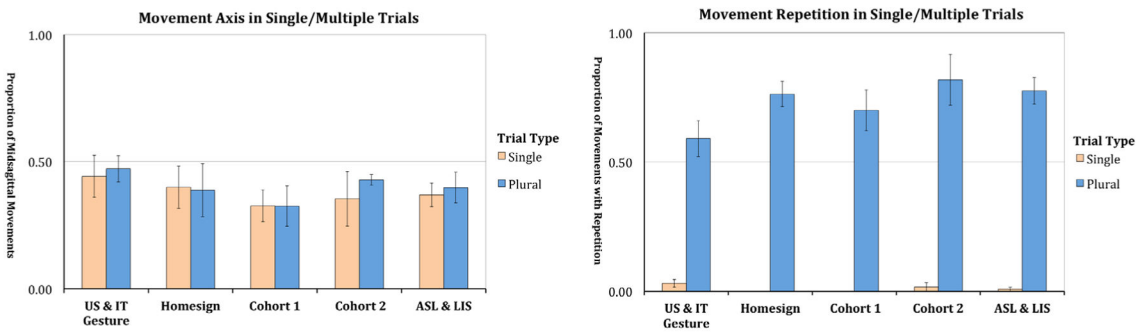

Fig. 6.

The proportion of responses with Midsagittal Movements (left graph) and Movements with Repetition (right graph) in Single Trials (orange bars) and Plural Trials (blue bars) produced by Silent Gesturers, Homesigners, NSL Cohort 1 signers, NSL Cohort 2 signers, and ASL/LIS signers. Error bars indicate standard errors.

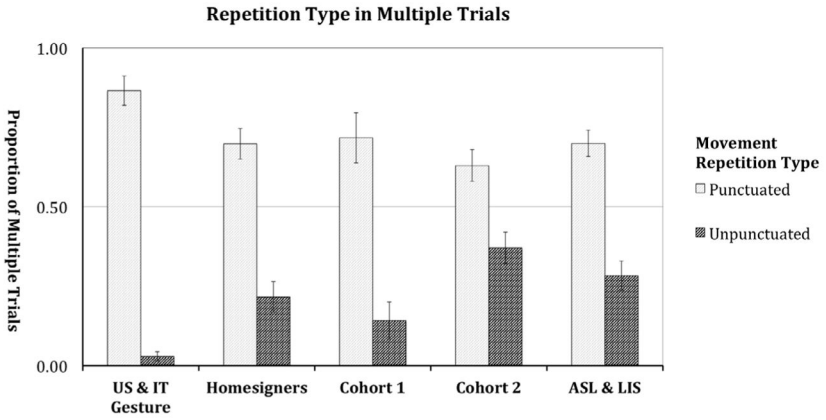

Fig. 7.

The proportion of responses containing movements with repetition classified according to manner—punctuated (light gray bars) vs. unpunctuated repetition (dark gray bars)—produced by Silent Gesturers, Homesigners, NSL Cohort 1 signers, NSL Cohort 2 signers, and ASL/ LIS signers in response to all Plural vignettes. Error bars indicate standard errors.

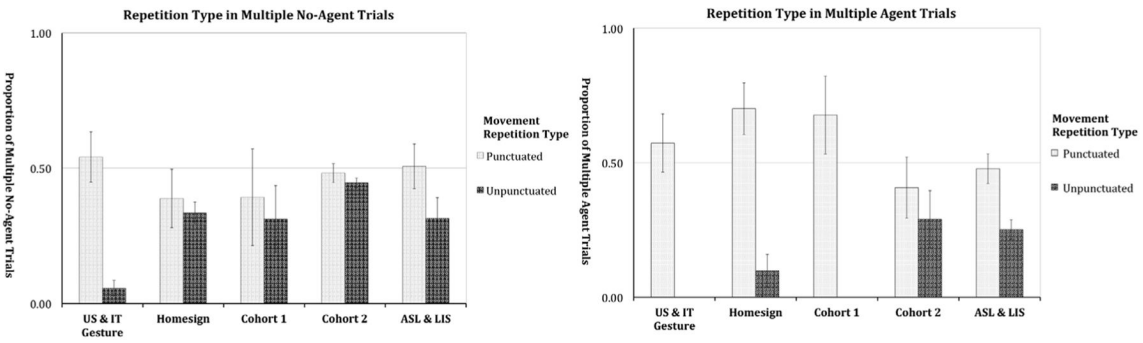

Fig. 8.

The proportion of responses containing *movements with repetition* classified according to manner—punctuated vs. unpunctuated repetition—produced by Silent Gesturers, Homesigners, NSL Cohort 1 signers, NSL Cohort 2 signers, and ASL/ LIS signers in response to Plural vignettes with No-Agent (left graph) and Plural vignettes with an Agent (right graph). Error bars indicate standard errors.

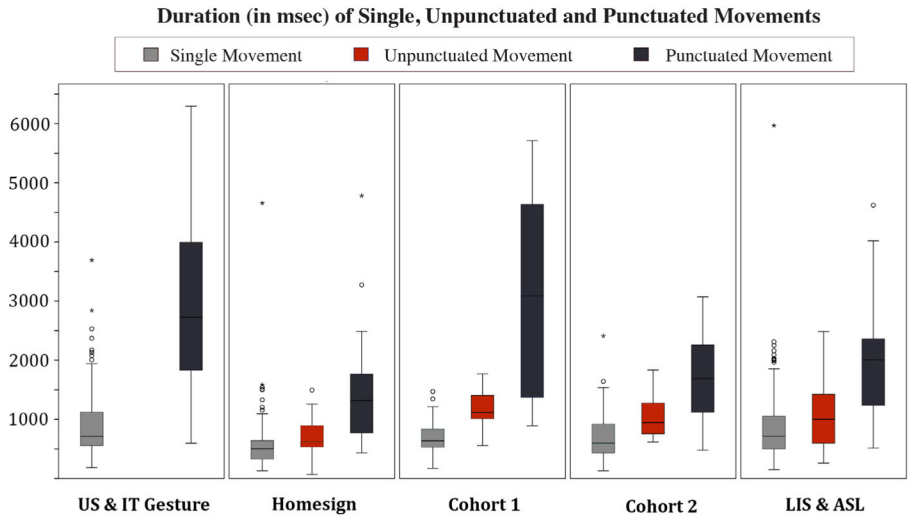

Figure 9.

Mean duration (in msec) of three movement types (single, unpunctuated repetition, and punctuated repetition) for Silent Gesturers, Homesigners, NSL Cohort 1, NSL Cohort 2, and ASL/LIS. Silent Gesturers produced too few Unpunctuated Movements (see text) to analyze meaningfully.