The emergence of the formal category "symmetry" in a new sign language

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Logical properties such as negation, implication, and symmetry, despite the fact that they are foundational and threaded through the vocabulary and syntax of known natural languages, pose a special problem for language learning. Their meanings are much harder to identify and isolate in the child's everyday interaction with referents in the world than concrete things (like spoons and horses) and happenings and acts (like running and jumping) that are much more easily identified, and thus more easily linked to their linguistic labels (*spoon*, *horse*, *run*, *jump*). Here we concentrate attention on the category of symmetry [a relation R is symmetrical if and only if (iff) for all x, y: if $R(x,y)$, then $R(y,x)$], expressed in English by such terms as *similar*, *marry*, *cousin*, and *near*. After a brief introduction to how symmetry is expressed in English and other well-studied languages, we discuss the appearance and maturation of this category in Nicaraguan Sign Language (NSL). NSL is an emerging language used as the primary, daily means of communication among a population of deaf individuals who could not acquire the surrounding spoken language because they could not hear it, and who were not exposed to a preexisting sign language because there was none available in their community. Remarkably, these individuals treat symmetry, in both semantic and syntactic regards, much as do learners exposed to a previously established language. These findings point to deep human biases in the structures underpinning and constituting human language.

language emergence | sign language | logical structure of language | homesign | symmetry

To a first approximation, language describes the entities—the lions, spoons, puppies—and events—the running, chasing, eating—that figure in everyday life. However, an immediate counter, or at least refinement, of this view of language is that events, as well as entities, can be construed in more than one way, a distinction that is reflected in the lexical forms and structures of all known languages. For example, the same event could equally be described as "a lion chasing a gnu" or "a gnu fleeing a lion." What is seen in the ambient world is the same, but, in one case, it is viewed from the perspective of the causal agent (the lion) and, in the other, from the perspective of the potential victim (the gnu). Assembling a sentence is not just a matter of mentioning the gnu and the lion and the running, but necessarily entails a perspective on the events under description, their *construal*. Indeed, it is not the events per se that sentences encode; it is their construals.

This presents a puzzle: the construal of an event is abstract and not observable per se. How would a learner of a language come to appreciate the relevant encoding, and how would such distinctions arise in a new language?

We examine the foundations of this core distinction between observation and construal by first gleaning insights about its encoding from a mature language, English. We then explore experimentally whether and when such a distinction arises in a newly emerging language, Nicaraguan Sign Language (NSL). We turn our magnifying glass on two properties of relations that reside at that abstract level at which language construes event structure: symmetry, which is encoded in predicates that relate two entities; and reciprocity, which relates propositions.

We begin with an illustrative example, *kiss*, depicted in Fig. 1. *Kiss* is an important case because it reveals that the very same event can be construed as a single act or as two acts. Consider kissing as shown in Fig. 1*A*, a single symmetrical act involving two participants viewed collectively, expressed "John and Mary kiss." (Note that one cannot say, at peril of awkwardness or ungrammaticality, just "John kisses.") Here *kissing* is a symmetrical relation. In contrast, Fig. 1*B* depicts two simultaneous acts, John kissing Mary (on the hand) and Mary kissing John (on the hand). This second case cannot be expressed as "John and Mary kissed," only as "John and Mary kissed each other"—tantamount to a conjoined pair of minimal transitive sentences (propositions) in which the semantic roles of the participants in the sentences are reversed. The fact that there are two acts is obligatorily marked in the syntax by the pronominal residue of the second proposition, "each other." *Kissing* in Fig. 1*B* is not a symmetrical relation; it is a reciprocal relation. Note further, if we return to Fig. 1*A*, that it is possible to construe this event, too, as two acts, one in which John kisses Mary and another in which Mary kisses John; in other words, as a reciprocal relation between two propositions. A symmetrical relation can always be construed as two reciprocal relations because there is a one-way entailment between symmetry and reciprocity: every symmetrical entails its reciprocals. So, if John and Mary meet, it follows as a logical necessity that John meets Mary and Mary meets John.

We first formally define symmetry and its cousin, reciprocity, and then ask whether the abstract level at which their meaning is construed is so fundamental to human language that the distinction between symmetry and reciprocity is encoded in an emergent language. A young language might, from its inception,

Significance

Nicaraguan Sign Language (NSL), invented by a small group of heretofore linguistically isolated children, has developed over a flash of evolutionary time, approximately 40 y. We present evidence that NSL quickly became a linguistic system that parallels known mature languages, with a syntax for describing the logical structural features of *symmetry*. This appearance of essentially the same forms to express the same abstract content points to a significant, and likely universal, component in the design and acquisition of natural language.

A **Symmetrical Kissing**
One Act

B **Reciprocal Kissing**
Two Acts
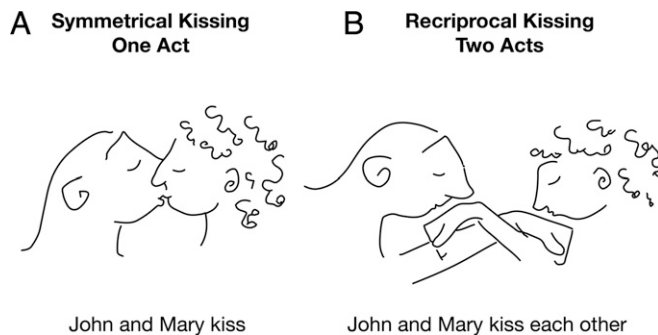
John and Mary kiss

John and Mary kiss each other

Fig. 1. (*A*) Symmetrical relation in which John and Mary kiss (a single act with a collective subject). (*B*) Two simultaneous acts in which John kisses Mary and Mary kisses John, a reciprocal relation.

encode the abstract construal of an event and thus make a formal distinction between symmetry (*kissing* in Fig. 1*A*) and reciprocity (*kissing* in Fig. 1*B*). Alternatively, young languages might begin by focusing on the observable aspects of events, and thus collapse the distinction between symmetrical and reciprocal relations, if they encode these relations at all. We examine the earliest stages of a newly developing sign language, NSL, to address this question.

Symmetry and Reciprocity

Symmetrical figures in geometry are those that are invariant under such transformations as rotation, reflection, translation, and scale. In logic, symmetry is a property of binary relations, defined as:

i) A relation R is symmetrical if and only if (iff) for all x, y: if $R(x,y)$, then $R(y,x)$

Symmetry is a fundamental property of nature and of mind. It is threaded through natural language pertaining to varying kinds of comparison falling under definition (*i*). Symmetrical expressions share meaning only at this abstract level; there is no physical commonality in the world to which they all refer. For example, the word "cousin" expresses a symmetrical relation: If A is a cousin to B, then B is a cousin to A. The word "niece," a related kinship term, does not express such a symmetrical relation. Symmetrical meanings are found in almost every part-of-speech category; for example, noun (*cousin*), adjective (*similar*), verb (*match*), and preposition (*near*). Symmetrical words may pertain to abstract states, such as *equality*, or concrete actions, such as *meeting*.

Symmetry is a property of a relation between two entities, the *arguments* of the relation. With a symmetrical predicate, the two entities may be considered jointly, as a collective. For this reason, a symmetrical predicate sounds natural with a plural subject (as in *the shirt and hat match*; or *the clothes match*) and awkward with a singular subject (as in *the hat matches*) (1–3). *The hat matches* sounds awkward for the same reason that *the sound of one hand clapping* is a category error whose only reading is ironic or metaphoric. Accordingly, *Jim and Donald meet* is not conceived as two acts of meeting, but rather as a single meeting event involving two participants viewed collectively (4).*

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*Symmetrical words often appear in subject-complement constructions, such as *North Korea is similar to Red China*, as Amos Tversky (5) famously demonstrated. Its complementary sentence with noun phrases reversed (*Red China is similar to North Korea*) is not treated by research participants as equivalent in similarity value. That is, for such cases, Tversky wrote, the symmetrical entailment does not hold. He therefore concluded that similarity is not psychologically symmetrical. However, in subsequent experimentation and discussion, Gleitman et al. (4) showed that this nonparity comes from the syntactic structure of the sentence (which is asymmetrical and leads to a figure/ground interpretation), not from the word *similar* (which remains lexically symmetrical). Prior research has shown appreciation of figural symmetry prelinguistically (by age 4 mo [6]) and understanding of both symmetrical and reciprocal construal and syntax in English speakers by age 4 y and perhaps earlier (7, 8).

Reciprocity, as described here, is a relation between two propositions in which, syntactically speaking, their argument positions, subject and complement, are reversed. The semantic effect is to reverse the roles of actor and theme or, more informally, *doer* and *done-to*, as in "the man tapped the woman and the woman tapped the man," most commonly appearing with the second clause pronominalized, as in "the man and the woman tapped each other."† It is not possible to express this reciprocity without it, as in "the man and the woman tapped."

Events of *kissing* (Fig. 1*A*) or *meeting* are thus construed, at times, as one symmetrical collective act, and, at other times, as two acts with participants in reversed roles. This fact presents a challenge to theories of language acquisition and language emergence simply because this abstract level of meaning cannot be directly observed. Our goal is to probe the earliest forms of expression of this abstract distinction in a newly formed language. Two people meeting each other is, like kissing, a symmetrical event, but two people punching each other (as illustrated in our stimuli; Fig. 2) also looks symmetrical. Despite this surface-level similarity, established languages treat these two types of events differently—symmetrical structures are used to describe two people meeting each other, whereas reciprocal structures are used to describe two people punching each other. Here we ask whether an emerging language encodes the superficial similarity between these two types of events (and thus uses the same forms to represent *meeting* and *punching*), or whether the emerging language encodes the deeper abstract differences between the events (and thus uses a symmetrical form to represent *meeting* that is distinct from the reciprocal form used to represent *punching*).

NSL

A Brief History. NSL was created by a community of deaf children brought together in schools for special education in Nicaragua, starting with an initial group of 50 students in Managua in the mid-1970s (9, 10). Until that time, deaf people in Nicaragua had few opportunities to interact, and there were no opportunities for cross-generational contact. Consequently, there was no sign language available, and children's hearing losses prevented acquisition of spoken Spanish. Previous research has documented the gesture systems, called *homesigns*, that deaf children in this situation develop to communicate with hearing family members and friends (11–13). Education at the schools was initially carried out in spoken and written Spanish, which few students learned successfully. Meanwhile, on the bus and in the schoolyard, deaf children communicated gesturally, quickly moving beyond their various homesign systems. Successive waves of children entering preschool year after year acquired the growing language and further elaborated it (14–16). Today, NSL is a rich, complex language that is the primary means of communication for more than 1,500 deaf people, ranging from 4 to 55 y of age. However, many homesigners do not enter the deaf community and therefore do not acquire NSL; they continue to use their homesign systems into adulthood and, in this way, represent the initial resources out of which NSL emerged. This situation offers an unprecedented opportunity in which the originators of the language are still living, offering a view of its earliest stages and enabling us to observe how a language begins and changes—or, in some ways, remains the same—as it evolves.

The present study chronicles the evolution of event construal in symmetrical and reciprocal expressions in homesign and in NSL as it emerges during its first 50 y. Previous work has established that, in many aspects, including its vocabulary and structure, this young language shares core properties with mature spoken and signed languages (14–19), though—as with any

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†Other languages have different devices for marking reciprocity, e.g., the French clitic pronoun, *Pierre et Jean se reconnaissent*.)

Bidirectional Test Items
Symmetrical Reciprocal

Transitive Control Items
Control for Symmetrical Control for Reciprocal

Fig. 2. Examples of stimulus items. The bidirectional test items, designed to elicit symmetrical and reciprocal construals, are displayed in the first two panels. The unidirectional items that serve as controls for each bidirectional type are displayed in the third and fourth panels.

particular language—it has several novel twists and grace notes in its architecture that are rare or peculiar to itself. One of these grace notes is relevant to our analyses: a complementary argument structure (CAS) used to express events that involve two people.

The Architecture of Sentences in NSL: Complementary Argument Structure. In NSL, an event with a single actor is expressed with a simple (apparently intransitive) sentence structure; the subject precedes the verb, as in "woman jump." Events that involve two animate participants, however, are generally expressed with two verbs. Accordingly, an event like *John pushes Bill* would be rendered with two verbs, with one verb highlighting the *doer's* perspective of the event ("push") and the other verb highlighting the *done-to's* perspective ("be-pushed") (Fig. 3, *Bottom Left*). In the sentence, the two verbs are often preceded by the two nouns in a NVNV or NNVV pattern, as in "John push Bill get-pushed"; "John Bill push get-pushed"; or even "John Bill push fall" (15). These two verbs together express a single event (i.e., there is one act of pushing taking place), in what may well be a serial verb construction (20–22). For comparison, the English sentence *Ellen finished eating* uses two verbs to represent two aspects of a single eating event. Note that, in the CAS construction, the arguments of the two verbs are complementary; specifically, the patient of one verb (Bill, who is the *done-to* of "push") corresponds to the theme of the other verb (Bill is the *experiencer* of "be-pushed").

Previous research has identified these CAS constructions in transitive sentences that describe one act involving two people (e.g., Mary punches John). Here we use the fact that the CAS construction signals transitivity in NSL to determine how signers construe an act like *meet*. If *meet* is construed as two simultaneous reciprocal acts like *punch* (John meets/punches Mary and Mary meets/punches John), NSL signers should use the CAS construction to describe both *meet* and *punch*. If, however, *meet* is construed as a single act performed collectively by John and Mary (i.e., John and Mary meet), NSL signers ought to shy away from using the CAS construction for *meet*.

Verb Forms in NSL. We also examine the form of the verb used to describe acts such as *meet* and *punch*. In our stimuli (as described later), when John and Mary meet or punch each other, the two participants perform the same acts at the same time. Signers can represent this fact by producing two simultaneous mirror-image movements (Fig. 4, *Lower Left*): the left hand representing John, or John's punching hand, moves to the right just as the right hand representing Mary, or Mary's punching hand, moves to the left. This form is a good representation of a single symmetrical act performed collectively by John and Mary. However, the form does not highlight the fact that there are two acts, an essential component of reciprocals.

Here we ask whether NSL signers' verb forms derive their structure directly from the acts in the world they describe. If so, the verb forms for our stimuli ought to contain mirror-image movements in descriptions of symmetrical and reciprocal events. Alternatively, signers might use verb forms that cap-

ture the construal of the two movements as symmetrical or reciprocal. If so, the verb form for symmetrical acts ought to contain simultaneous mirror-image movements, but the form for reciprocal acts might not.

Stimuli Designed to Elicit Symmetrical and Reciprocal Construals

Videotaped Stimuli. To test whether and how NSL signers and homesigners differentiated symmetrical and reciprocal construals of events, we elicited short descriptions of single events, each containing two actors and presented on a laptop computer. Target video clips depicted bidirectional events in which a woman performs an act on a man and, at the same time, the man performs the same act on the woman. These target events were of two types, designed to elicit symmetrical or reciprocal construals. Observers tend to construe the event in the first panel of Fig. 2 as two persons acting collectively to perform a single act of *high-fiving*, a symmetrical construal. In contrast, observers tend to construe the event in the second panel of Fig. 2 as two persons, each acting on one another, in two acts of *punching*, a reciprocal construal. As noted earlier with respect to *kiss*, it is plausible (although perhaps not likely) to construe the *high-fiving* event in the first panel as two simultaneous reciprocal acts. It is also possible to construe the *punching* event in the second panel as a single act, say of *boxing*, particularly if the two punchers were wearing boxing gloves and standing in a ring. The depictions used as stimuli in our study did not include the extra contextual support that might motivate
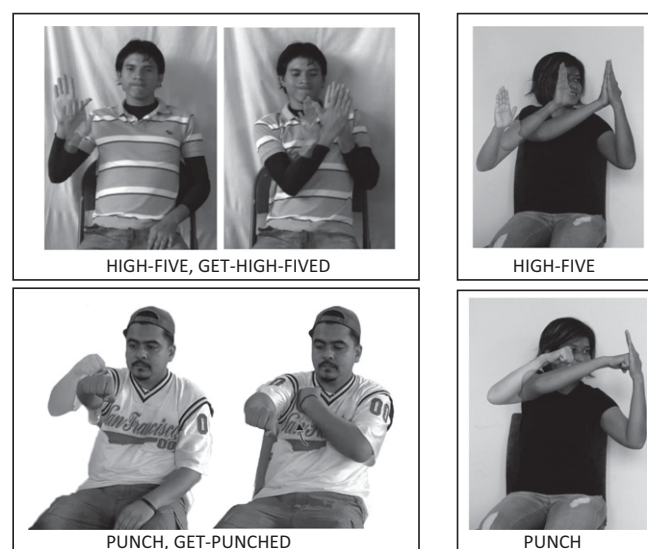
HIGH-FIVE, GET-HIGH-FIVED   HIGH-FIVE

PUNCH, GET-PUNCHED   PUNCH

Fig. 3. Examples of two-verb CAS (*Left*) and one-verb (*Right*) constructions elicited to describe the same types of *high-fiving* and *punching* events. These examples show nonmirrored forms. The mirrored verb form can also be used in both one-verb and two-verb CAS constructions; accordingly, verb form (mirroring) and sentence structure (CAS) are coded independently.

Mirrored HIGH-FIVE   Non-Mirrored HIGH-FIVE

Mirrored PUNCH   Non-Mirrored PUNCH

Fig. 4. Examples of mirrored (*Left*) and nonmirrored (*Right*) verb forms elicited in descriptions of a *high-fiving* event designed to elicit a symmetrical construal and its control, and a *punching* event designed to elicit a reciprocal construal and its control.

seeing two reciprocal acts of punching as a single symmetrical act, "boxing"; we therefore loaded the dice in favor of a reciprocal construal of the *punching* (and *tickling*) events that we presented.

In addition, for each target event, we created a matching unidirectional control event, in which one of the actors acted upon the other. The control events were of two types, matching the events designed to elicit symmetrical or reciprocal construals (Fig. 2, third and fourth panels). In the control for symmetrical *high-fiving*, a man slapped a woman's static raised hand, and, in the control for symmetrical *meeting*, a woman approached a man. Similarly, in the control for reciprocal *punching*, a woman punched a man, and, in the control for reciprocal *tickling*, a man tickled a woman. Each signer viewed four bidirectional videos (two designed to elicit symmetrical construals, two designed to elicit reciprocal construals) and four matched unidirectional control videos.

Coding. Responses were coded according to (*i*) the form of the verb and (*ii*) the construction in which the verb appeared.
Verb form coding. In each utterance, we identified the verbs that represented the target events (528 tokens in total) and coded each verb as mirrored (two identical articulators moved in an identical, mirror-image path relative to a central plane, e.g., from the periphery to the center, toward each other) or as nonmirrored (only one articulator, or two articulators with different formations moved asymmetrically). Fig. 4 presents examples of mirrored (*Left*) and nonmirrored (*Right*) verb forms for events designed to elicit symmetrical construals and their controls (*Top*) and reciprocal construals and their controls (*Bottom*).
Verb construction coding. We coded whether response utterances contained more than one verb and classified the relation between

the two verbs with regard to the semantic roles of their respective arguments. We coded the expression as exhibiting CAS if the patient of one of the verbs corresponded to the agent or experiencer of the other. Accordingly, one verb highlights the agent's perspective of the event, whereas the other verb highlights the patient's perspective. Fig. 3 presents examples of two-verb CAS (*Left*) and one-verb (*Right*) constructions in response to events designed to elicit symmetrical construals and their controls (*Top*) and reciprocal construals and their controls (*Bottom*).

Statistical Analyses. We used a logistic mixed-effects regression with random effects for signers and stimulus item to analyze the NSL signers' verb form and CAS data, using each individual's year of entry into the community to explore changes over time in the emerging language. Homesigners are not part of the NSL-signing community and do not interact with one another; we therefore report data for each homesigner individually. Because we find no year of entry effects, we present grouped data in the text; data for each individual (including the four homesigners) can be found in the *SI Appendix*.

Verb Form: Mirroring

All 23 NSL signers and four homesigners produced both mirrored [mean (M) = 5.37; *SD* = 2.29] and nonmirrored (M = 17.41; *SD* = 5.44) verbs. If signers are capturing the unidirectionality of the control event in their verb forms, nonmirrored verbs should be the preferred form in both types of unidirectional control items, which is precisely what we found (Fig. 5 *A* and *B*, *Right*). In contrast, we found that verb forms differed in the two types of bidirectional test items (Fig. 5 *A* and *B*, *Left*). As might be expected, signers frequently captured the bidirectionality of a symmetrical act by using a mirrored form (0.84). However, they preferred to use the nonmirrored form for reciprocal acts despite the fact that the two acts in these particular events visually mirror one another: only 0.22 of these verb forms were mirrored. It is, of course, physically possible to reproduce the bidirectionality of the reciprocal acts in a verb's form, and signers occasionally did so (Fig. 5*B*, *Left*). Nevertheless, this was not the preferred response.

To statistically investigate the distribution of the mirrored and nonmirrored verb forms in the NSL signers, we performed a logistic mixed-effects regression with random effects for signer (*SD* = 0.36; *SI Appendix*, Table S1). Nonmirrored verb forms were used significantly more often for the reciprocal test and control items than for symmetrical test and control items (β = 2.68, $P < 0.001$) and more often for items in the unidirectional test frame than for items in the bidirectional test frame (β = 3.50; $P < 0.001$). There was no effect of year of entry (β = −0.01; P = 0.483), suggesting that these patterns have been present since the language first emerged.

Our statistical analysis lacked the power to detect an interaction within the regression model. However, the telling pattern is that nonmirrored verb forms were used more often for reciprocal test items than for symmetrical test items. We therefore analyzed each individual's data, categorizing individuals into those who did and did not follow this pattern. We found that all 23 NSL signers ($P = 0.000002$, binomial test) produced more nonmirrored forms in reciprocal than symmetrical test items, as did three of the four homesigners (the fourth homesigner displayed the reverse pattern; *SI Appendix*, Fig. S1 presents verb form data for each signer and homesigner).

As can be seen in *SI Appendix*, Figs. S1 and S2, NSL signers entered the community, presumably as homesigners, during the first decade, nine entered at various points during the second decade, and seven entered during the third decade. The fact that all of these individuals used more mirrored verb forms on the bidirectional symmetrical test items than on the bidirectional reciprocal test items, independent of when they first entered the
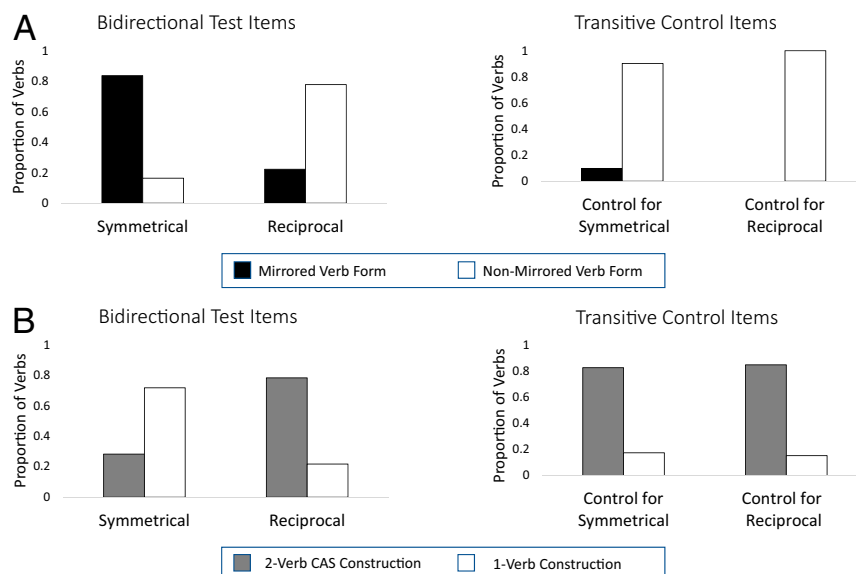
Fig. 5. (*A*) Proportion of verbs produced by NSL signers that were mirrored (black) and nonmirrored (white) in the signed descriptions of each type of event. (*B*) Proportion of utterances produced by NSL signers that contained a two-verb CAS construction (black) or a one-verb construction (white) in the signed responses to each type of event. Proportions are weighted averages, calculated per individual and then averaged across individuals within the group.

community, suggests that not only was this pattern present when the language was first formed, but also that transmitting the language to subsequent cohorts of signers had no further effect on the pattern. Moreover, the fact that three of the four homesigners also used mirrored forms more often for symmetrical test items than for reciprocal test items suggests that a deaf individual, surrounded only by hearing individuals who do not share the homesigner's gesture system (23, 24), can capture the abstract distinction between symmetrical and reciprocal construals of events in their verb forms. We now explore the multisign constructions that contain these verbs.

Verb Constructions: Transitive CAS

All participants produced sentences that contained two verbs with CAS constructions. On average, more than two thirds of responses included CAS constructions (M = 0.71; SD = 0.16). Responses to the two types of transitive control events confirm that the CAS construction can be taken as an index of transitivity: NSL signers (and homesigners) used the CAS construction in a majority of their utterances describing the two types of control events (0.83 transitive controls for symmetricals, 0.85 transitive controls for reciprocals; Fig. 5*B*, *Right*). They also used the CAS construction in reciprocal test items (0.78), indicating that these sentences, too, are transitive. In contrast, the CAS construction was used infrequently in symmetrical test items (0.28), suggesting that these sentences are not transitive and instead express an intransitive syntax (i.e., *the man and woman high-fived*; Fig. 5*B*, *Left*).

Even though the symmetrical and reciprocal test items both involved two actors acting simultaneously and identically with respect to each other (Fig. 2), their event structures were broken down differently. Symmetrical test items were typically described using a single verb with a conjoined subject, as in "man woman high-five" (Fig. 6), whereas reciprocal test items were described using multiple (as many as four) verbs in CAS constructions, each verb representing a different perspective on the separable subevents, as in "man woman punch get-punched punch get-punched" (Fig. 7).

To statistically investigate the distribution of the CAS verb constructions in the NSL signers, we performed a logistic mixed-effects regression with random effects for signer (*SD* = 0.40; *SI Appendix,* Table S2). NSL signers used CAS constructions sig-

nificantly more often when describing reciprocal test items and their transitive controls than when describing symmetrical test items and their transitive controls. There was a main effect of event type (symmetrical vs. reciprocal, β = 2.49, *P* < 0.01) and frame (bidirectional test items vs. unidirectional controls, β = 2.51, *P* < 0.01). There was also a significant interaction between event type and frame (β = −2.33, *P* < 0.01): CAS constructions were prevalent in responses to the reciprocal test items and both types of unidirectional transitive control items, but not in responses to symmetrical test items, in which noncomplementary verb constructions were preferred. There was no effect of year of entry (β = 0.03, *P* = 0.64), suggesting that this pattern has been present since the language first emerged.

We again analyzed the data at the individual level and found that the telling pattern—more transitive CAS constructions used for reciprocal test items than for symmetrical test items—was found in 18 of the 23 NSL signers (*P* = 0.006, binomial test; *SI Appendix,* Fig. S2 presents individual CAS data). The fact that 18 of the 23 signers used more two-verb CAS constructions on the bidirectional symmetrical test items than on the bidirectional reciprocal test items, independent of when they first entered the community, suggests that the pattern was present when the language was first formed and that transmitting the language to subsequent cohorts of signers had no further effect on the pattern. Interestingly, however, unlike the verb form findings, only one of the four homesigners showed the verb construction pattern (*SI Appendix,*
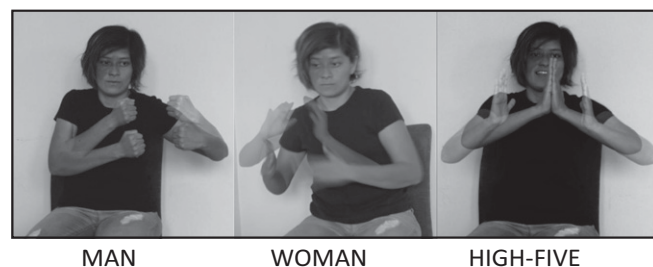

Fig. 6. The symmetrical sentence meaning "the man and woman high-five (each other)" includes a single verb, "high-five," which is mirrored in form.

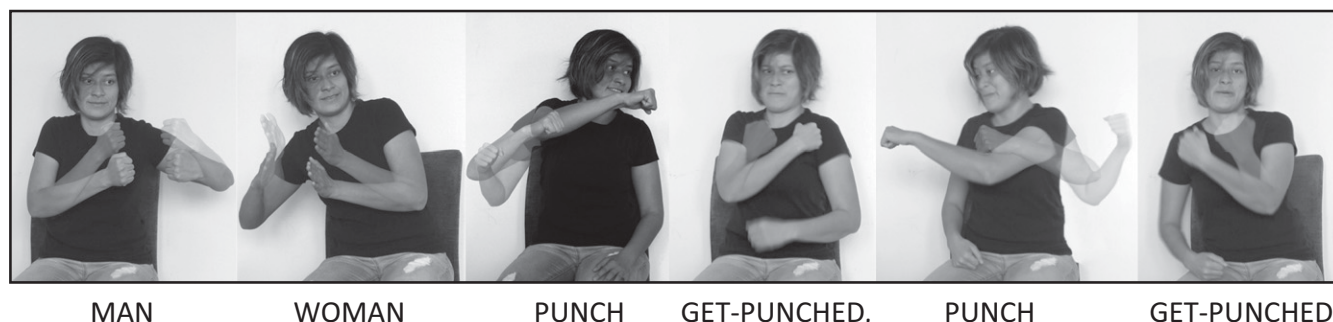| MAN | WOMAN | PUNCH | GET-PUNCHED, | PUNCH | GET-PUNCHED. |

Fig. 7. The reciprocal sentence meaning "the man and woman punch each other" includes four variants of the verb "punch," none of them mirrored in form, arranged in two CAS pairs.

Thus, although it is possible for an individual homesigner to make a distinction between symmetrical and reciprocal construals of events by using verb constructions, not all individual homesigners make this distinction. Nevertheless, the use of verb constructions for this purpose does seem to become a robust part of the communal language as soon as the language is shared among users (i.e., as soon as the homesigners join a community and begin to form a shared system).

Conclusion

We found that all of the NSL signers and homesigners in our study made formal distinctions in their descriptions of events designed to elicit symmetrical vs. reciprocal construals, despite the visual similarity of the paired depicted events. Reciprocal events were described by using the machinery developed to describe the control transitive events, whereas symmetrical events were described quite differently.

At the word level, the striking result is that not all bidirectional events that look symmetrical on the surface are represented by using mirroring. When two people punch each other, the event can look just as symmetrical as when two people high-five each other. Nevertheless, the mirrored form was used primarily for events that are abstractly construed as symmetrical—a single event in which two participants act as one—not for two simultaneous reciprocal events, even though these reciprocal events appear symmetrical as we observe them. All signers, even homesigners, have this intuition, and thus make a distinction between symmetrical and reciprocal construals of events at the word level. The fact that three of the four homesigners made this distinction suggests that having a formal distinction between symmetrical and reciprocal construals of events is central to human language—so central that it will be introduced into a linguistic system even when that system is created by a deaf individual without the support of a community of signers.

At the sentence level, verbs describing bidirectional events designed to elicit reciprocal construals (as well as unidirectional events involving one person acting on another person, that is, asymmetrical events) are produced within CAS constructions. These are transitive constructions for NSL signers, thus confirming that reciprocal events are construed as transitive. The striking result here is that verbs describing symmetrical events are rarely produced in CAS constructions, signaling that symmetrical events are not typically construed as transitive. NSL signers displayed this pattern regardless of their year of entry into the deaf community. Note that only one of the four homesigners showed the pattern (one showed the reverse pattern, and two showed no difference between symmetricals and reciprocals). The CAS construction was thus not likely to have been used in a discriminating way in the homesign systems that contributed to early NSL (although the homesigners may have used a different device to mark the distinction at the sentence level). Importantly, however, as soon as

the first group of homesigners came together and developed a shared communication system, they converged on the CAS construction as a formal marker of transitivity, and consequently solidified this symmetrical/reciprocal distinction at the sentence level. Marking the distinction between symmetrical and reciprocal construals of events at the sentence level seems to be more fragile than marking the distinction at the verb level (more homesigners made the distinction at the verb level than at the verb construction level). Nevertheless, the verb construction distinction was there to be picked up (even if it was present in only a few homesign systems) and consequently spread rapidly when a community was formed.

In summary, the remarkable fact is that both English speakers and NSL signers distinguish between symmetricals (one event involving a collective agent, described by one nontransitive clause) and reciprocals (two events involving two agents, described by two transitive clauses). These findings, taken together, suggest a common core of conceptual distinctions and grammatical means for the foundational formal property of symmetry. The fact that this sameness is found under radically different input conditions highlights that unlearned conceptual forces are at work in the creation of universally shared language structure. Perhaps we have failed to discover how this distinction is "learned" because it was there from the beginning, in the earliest moments of language emergence, prefigured in the conceptual underpinnings that make language acquisition possible.

Materials and Methods

Participants. A total of 27 deaf individuals in Nicaragua participated in the study. Four were adult homesigners (one female, three male; mean age, 24 y; age range, 20–29 y). The homesigners had no known congenital cognitive deficits, had not learned spoken or written Spanish, and had not acquired NSL. None of the homesigners had attended school regularly, nor were any of them members of the deaf community. They did not know or interact with one another. Each had developed an individual homesign system (13) that was used to interact socially with hearing friends and family. The remaining 23 were NSL signers, categorized according to the year that each individual entered the deaf community, which ranged from 1974 to 1998 (10 female, 13 male; mean age, 30 y; age range, 18–45 y). All NSL signers entered the community by age 6 y, typically upon school entry (mean age at entry, 4.3 y; range, 2.1–5.7 y), and all used NSL as their primary daily language. This study was approved by the institutional review board of The University of Chicago (protocol 97–074). All participants were provided with a written consent form, which was translated to NSL or the participant's homesign system to assure all participants understood the content. Participants read and signed the consent form before participating in the study.

Procedure. Each participant viewed a series of video clip stimuli on a laptop computer, and was asked to describe the event in each clip to a conversation partner. NSL signers related the events to a peer signer; homesigners related the events to a family member who was a frequent communication partner.

Coding Utterances. All responses were glossed and coded at the utterance level (by M.F., who has 10 y of experience transcribing and coding NSL). Most

responses consisted of a single utterance; in the occasional case in which multiple utterances were produced, utterance boundaries were based on semantic criteria and prosodic cues, such as a lowering of the hands or an extended pause. These boundaries were usually quite clear. No prosodic analysis was carried out beyond the identification of utterance boundaries.

Coding Verb Forms. In each utterance, we examined the verbs that expressed the target events. These included known NSL signs, as well as iconic depictions of actions and conventional Nicaraguan gestures that had been recruited into homesigners' gesture systems. In all, 615 verb tokens were analyzed.

The form of each verb was coded as mirrored or nonmirrored based on the articulators used (hands, head, or torso) and their movements (Fig. 4). To be classified as mirrored, a sign must use two identical articulators (e.g., the two hands or arms) in the same formation (e.g., the same handshape or arm position) moving in an identical, mirror-image motion relative to a central plane (e.g., moving from the periphery to the center, toward each other). Accordingly, clapping the hands in front of the chest would be coded as a mirrored sign. In contrast, signs that used only one articulator, or that used two articulators with differing formations or movements, were classified as nonmirrored. Accordingly, hitting a flat hand with a fist would be classified as a nonmirrored sign.

Coding Verb Constructions. We noted the number of verbs in an utterance. For responses with more than one verb, we classified the relation between the verbs with regard to the semantic roles of their respective arguments. NSL sentences typically include two verbs to describe a single transitive event, particularly when the event entails an animate agent acting on an animate patient, the case for all stimulus clips. Moreover, the two verbs have a CAS, such that the experiencer or subject of one of the verbs corresponds to the patient or object of the other. One verb thus highlights the agent's perspective of the event, whereas the other verb highlights the patient's perspective. In all, 213 utterances were analyzed.

Reliability. A second coder with 3 y of experience coding NSL analyzed 68 of the 615 verb tokens (~11% of the data); agreement was 94.1% between coders for verb form (mirroring). The second coder also analyzed 26 of the 213 utterances containing verbs (~12% of the data); agreement was 100% for verb construction (CAS).

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