Anaphora: Insights from Sign Language (Summary)[*]

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Abstract: Sign language anaphora is realized very differently from its spoken language counterpart. In simple cases, an antecedent is associated with a locus in signing space, and an anaphoric link is obtained by pointing towards that locus to recover its semantic value. It has been argued that this mechanism is an overt realization of the device of *coindexation* in formal syntax and semantics. Summarizing some of our recent work, we discuss two kinds of insights that sign language research can for this reason bring to the foundations of anaphora. First, in some cases the overt nature of indices in sign language makes it possible to bring overt evidence to bear on classic debates in semantics. We consider two: the first concerns the availability of *situation-denoting variables* in natural language (we argue that pointing signs can be situation-denoting in addition to being object-denoting); the other concerns the availability of *binding without c-command* (we suggest that sign language provides overt evidence for such a possibility). Second, in some cases sign language pronouns raise new challenges for formal semantics. We argue that the iconic component of sign language loci is a case in point; in the end, we suggest that loci may be simultaneously formal variables and simplified depictions of what they denote – which requires the construction of a *formal semantics with iconicity* to analyze their properties.

Note: The present piece aims at summarizing the results of Schlenker 2011a, b, c, 2012, to appear, Schlenker and Lamberton, to appear, and Schlenker et al., to appear; it heavily draws on these earlier articles in form and as well as substance.

In this summary of some of our recent research on sign language, we discuss three cases in which sign languages can bring new insights into the foundations of anaphora. These cases are of two sorts.
–First, we re-visit two classic semantic debates. One concerns reference to times and worlds (or situations); the other concerns the nature of variable binding. We suggest that in both cases the realization of sign language pronouns provides direct and overt evidence in favor of certain facts that must be inferred rather indirectly in most spoken languages.
–Second, we suggest that some iconic properties of sign language pronouns suggest a renewed view of semantic interpretation: in some cases, some geometric properties of signs appear to directly reflect properties of their denotations, which argues for a condition of 'formal iconicity' at the very core of a formal semantic account.

1 Background: Pronouns in Sign Language

Pronouns in sign language have been the object of considerable interest, in part because their realization seems to be so different from that of their spoken language counterparts: in simple cases, sign language pronouns are realized by way of pointing. For present purposes, one typical mechanism involves two steps: (i) first, an antecedent establishes a position in signing space, called a 'locus'; (ii) second, the pronoun is realized by pointing back towards this locus (but see for instance Schlenker 2011c for discussion of alternative realizations of anaphora). In (1), we see examples of locus assignment to expressions of direct reference (here proper names), definite descriptions and indefinite descriptions (only meaning can distinguish between the latter two).

In the following, sign language sentences are glossed in capital letters. Non-manual markings are omitted, except in expressions that include the pronouns under study; in this case, *re__* indicates that the signer has raised eyebrows during the production of the pronoun. Subscripts correspond to the establishment of locations ('loci') in signing space – thus *INFECTED*$_a$ is the word 'infected' signed in locus *a*. Letters are assigned from right to left from the signer's perspective – and in some examples we give a rough representation of the loci's positions using a diagram. Pronouns, glossed as *IX* (for 'index'), can point back towards previously established loci. In such cases, the locus is suffixed to the pronoun, so that *IX-a* is a pronoun that points towards (or 'indexes') locus *a*; the numbers *1* and *2* correspond to the position of the signer and addressee respectively. Importantly, indexes can also be used to *establish* a locus. *CL* stands for different classifiers, and *rep* for the repetition of a sign.

(1) a.   re__   re_____
     IX-1 KNOW $_a$BUSH IX-1 KNOW $_b$OBAMA.   IX-b SMART   BUT IX-a NOT SMART.'I know Bush and I know Obama. He [= Obama] is smart but he [= Bush] is not smart.'
     b.   re_____
     IX-1 KNOW PAST PRESIDENT IX-a IX-1 KNOW NOW PRESIDENT IX-b.   IX-b SMART BUT IX-a NOT SMART. 'I know the former President and I know the current President. He [= the current President] is smart but he [=the former President] is not smart.'
     c.
     IX-1 KNOW PAST SENATOR PERSON IX-a IX-1 KNOW NOW SENATOR PERSON IX-b.
     re_____
     IX-b SMART BUT IX-a NOT SMART. 'I know a former senator and I know a current senator. He [= the current senator] is smart but he [= the former senator] is not smart.'

Since there appears to be an arbitrary number of possible loci, it was suggested that the latter do not spell out morphosyntactic features, but rather are the overt realization of indices (Lillo-Martin and Klima 1990, Sandler and Lillo-Martin 2006). The latter are not overtly realized in spoken languages; the fact that they are in sign languages makes it particularly interesting to use them to bring new evidence to bear on questions of anaphora.

2   Temporal and Modal Anaphora

In the tradition of modal and tense logic, it was thought that expressions are only *implicitly* evaluated with respect to times and possible worlds: language was thought to be endowed with variables denoting individuals, but no variables denoting times or possible worlds. By contrast, several researchers have argued after Partee 1973 and Stone 1997 that natural language has time- and world-denoting variables – albeit ones that are sometimes realized as affixes (tense, mood) rather than as full-fledged pronominal forms. In other cases (e.g. the word *then* in its temporal and modal uses), it is reasonable to posit that spoken language indeed has an overt temporal/pronoun, but that it happens to be pronounced differently from individual-denoting pronouns. Now if a single abstract anaphoric system is indeed at work across nominal, temporal and modal uses, one might expect that some languages have a single pronoun that can be used across ontological categories in this way. It has been argued before that there are indeed morphological or syntactic similarities across these categories (Bittner 2001, Bhatt and Pancheva 2001). Here we make the simple suggestion that in ASL a single pronoun can have nominal, temporal, modal and also locative uses.

      The full argument has four steps:

1. As mentioned, nominal anaphora in sign language usually involves (i) the establishment of positions in signing space, called 'loci', for antecedents; (ii) pointing towards these loci to express anaphora. Both properties are also found in the temporal and modal domains.

2. When an ASL pronoun has two or three split antecedents, dual, trial or plural pronouns may simultaneously index all of them. The same fact holds in the temporal and modal domains.

3. Temporal and modal anaphora in ASL can give rise to patterns of inference that are characteristic of so-called 'donkey' pronouns (i.e. pronouns that depend on existential antecedents without being in their syntactic scope).

4. Temporal and modal anaphora gives rise to instances of 'locative agreement' in which the locus assigned to a nominal referent 'moves' in signing space depending on the location it is associated with. While this pattern has been described for spatial location, it applies to modal and temporal location as well.

Here we will be content to just illustrate the first step of the argument.

–It can be seen in (2) that the same possibilities are open for temporal anaphora as were displayed for nominal anaphora in (1): antecedents establish loci; pronominal forms retrieve them by way of pointing.

(2) a.   re__
[TOMORROW WILL RAIN]ₐ [DAY-AFTER-TOMORROW WILL SNOW]ᵦ.   IX-b IX-1 HAPPY.
re__
IX-a IX-1 WON'T HAPPY.
'Tomorrow it will rain and the day after tomorrow it will snow. Then [= the day after tomorrow] I will be happy but then [= tomorrow] I won't be happy.'
a'.   re__   re__
[YESTERDAY RAIN]ₐ [DAY-BEFORE-YESTERDAY SNOW]ᵦ.   IX-b IX-1 HAPPY.   IX-a

IX-1 NOT HAPPY.
'Yesterday it rained and the day before yesterday it snowed. Then [= the day before yesterday] I was happy but then [= yesterday] I wasn't happy.'
b.   re__   re__
[WHILE RAIN]ₐ TEND WARM. [WHILE SNOW]ᵦ TEND COLD.   IX-b IX-1 HAPPY.   IX-a

IX-1 NOT HAPPY.
'When it rains it is warmbutwhen it snows it is cold. Then [= when it snows] I am happy but then [= when it rains] I am not happy.'
c. *Context*: I went skiing during the holidays.
                                                                  re__   re__
[SOMETIMES RAIN]ₐ [SOMETIMES SNOW]ᵦ.   IX-b IX-1 HAPPY.   IX-a IX-1 NOT

HAPPY.
'Sometimes it rained and sometimes it snowed. Then [= when it snowed] I was happy but then [= when it rained] I wasn't happy].'

As can be seen, expressions of direct reference (here indexicals), *when*-clauses (which are semantically similar to definite descriptions of times), and existential time quantifiers (*sometimes*) can all give rise to patterns of anaphora involving the same pronoun *IX* as in the nominal case. Importantly, loci appear in the *usual* signing space, which is in front of the signer. Although the words for *tomorrow* and *yesterday* are signed on the 'time line', which is on a sagittal plane (*tomorrow* is signed in the front, *yesterday* towards the back), no pointing occurs towards it, at least in this case (but see Emmorey 2002 for discussion).

–Modal Indexing: While there are no clear world indexicals or world proper names, modals such as *can* are standardly analyzed as existential quantifiers over possible worlds; and *if*-clauses have occasionally been treated as definite descriptions of possible worlds (e.g. Bittner 2001, Schlenker 2004, Bhatt and Pancheva 2005). Both cases can give rise to locus indexing in ASL:

(3) a.   re__   re__
TOMORROW [POSSIBLE RAIN]ₐ [POSSIBLE SNOW]ᵦ.   IX-b IX-1 HAPPY.   IX-a IX-1

NOT HAPPY.
'Tomorrow it might rain and it might snow. Then [= if it snows] I'll be happy. Then [= if it rains] I won't be happy.'
b.   re__
[IF RAIN TOMORROW]ₐ WILL WARM. [IF SNOW TOMORROW]ᵦ WILL COLD.   IX-b IX-1
             re__
HAPPY. IX-a IX-1 NOT HAPPY.
'If it rains tomorrow it will be warm, but it it snows tomorrow it will be cold. Then [= if it snows] I'll be happy. Then [= if it rains] I won't be happy.'

We conclude that explicit anaphoric reference to times and possible worlds is possible in ASL – though our analysis leaves it entirely open whether these should be primitive categories or should be thought as different varieties of a more elementary category of *situations*.

3   Donkey Anaphora

Our second case study concerns the relation between pronouns and their antecedents – a foundational question that can also be illuminated by a property of sign languages that is rarely or never found in spoken languages. Specifically, by virtue of the device of locus establishment and retrieval, the connection between pronouns and their antecedents is sometimes made *formally explicit* in sign language. This matters because in some cases the nature of the relation between a pronoun has been hotly debated in the literature of spoken languages.

   The debate concerns the role of c-command (or 'scope', in traditional logical terminology) in the establishment of a binding relation between a pronoun and a quantificational antecedent. In some cases, it seems that such a relation is necessary. *No man drinks if he drives* has a meaning akin to *no man x is such that x drinks if x drives,* and *he* does appear in the scope of *no man*, as shown in (4)a. By contrast, *If no man drinks, he drives* does not allow the pronoun to be dependent on *no man* because *he* is not in the scope of *no man*, as shown in (4)b (to be felicitous, *he* would have to refer to some salient individual).
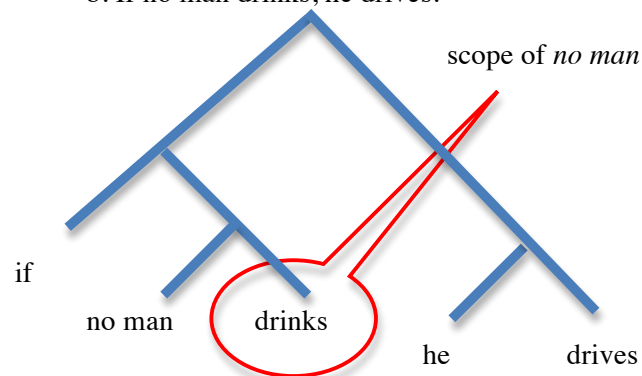
(4)   Scope in English I
      A pronoun must (usually) be in the scope of [= 'c-commanded by'] a quantifier it depends on.

a. No man drinks if he drives.

scope of *no man*

no man

drinks

if

he   drives

b. If no man drinks, he drives.

scope of *no man*

if
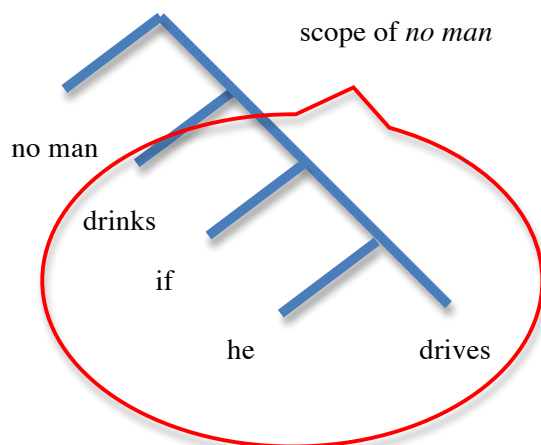
no man   drinks   he   drives

   When *no man* is replaced with *a man*, however, the facts change. *If a man drinks, he suffers* is naturally interpreted as: *If a man drinks, that man suffers*; the pronoun is dependent on the quantifier although it is not within its scope, as shown in (5).

(5)   Scope in English II
      A pronoun can depend on an existential quantifier without being in its scope.

If a man drinks, he suffers.

scope of *a man*

if

a man   drinks   he   suffers
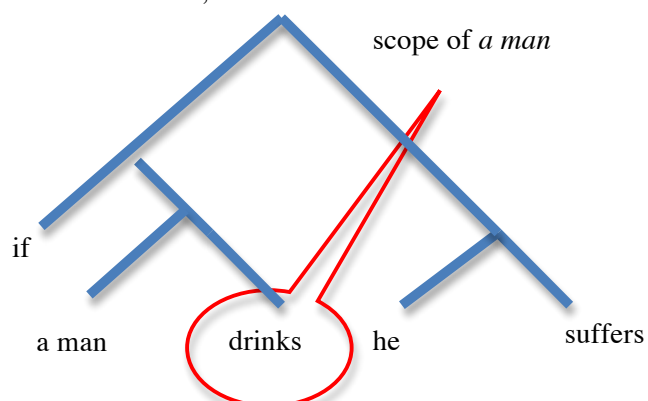
Because Geach originally discussed examples such as (6)a-b to show that a pronoun may depend on a quantifier without being in its scope, pronouns that have this property are called 'donkey pronouns' in the literature.

(6)   a. Every farmer who owns a donkey beat it.
       b. If a farmer owns a donkey, he beats it.

There have been two reactions to the problem of 'donkey pronouns'.

1. *Dynamic Semantics:* One view is that the logic underlying natural language is just different from standard logic. An entire movement, called 'dynamic semantics', has developed new rules that make it possible for a variable or a pronoun to depend on an existential quantifier or an indefinite without being in its scope (this may be done by treating indefinites themselves as variables, as in Kamp 1981 and Heim 1982; or by allowing existential quantifiers to bind outside of their syntactic scope, as in Groenendijk and Stokhof 1991).

2. *E-type analysis:* The opposing view is that no new logic is needed for natural language because the assimilation of pronouns (e.g. *he* in (5)a) to variables (e.g. *x* in (5)b) is incorrect.   On this view, the pronoun should be analyzed as a concealed description such as *the man,* or *the man who drinks* (e.g. Evans 1980; Heim 1990; Elbourne 2005); analyses that make this assumption are called 'E-type theories'. In some E-type theories, the pronoun is literally taken to come with an elided noun: *he = he* ~~man~~, where *man* is unpronounced and *he* is a version of *the* (this identity is morphologically realized in German, where *der* means both *the* and *he*) (Elbourne 2005). In other E-type theories, the pronoun is taken to have a richer semantic content, with for instance *he = the man who drinks* (e.g. Heim 1990). We henceforth restrict attention to the former analysis (Elbourne's), which is one of most elegant and articulated E-type theories currently on the market (see Schlenker 2011c for a discussion of other E-type theories in the present context).

Each analysis involves some refinements, which we will only briefly mention.

-The *dynamic analysis* develops rules of semantic interpretation that allow *he* in (5)a to depend on *a man* without being in its scope. This formal connection is taken to be represented in language through unpronounced variables similar to those of logic. Thus the sentence *If [a man]$_x$ drinks, he$_x$ suffers* is taken to include a variable *x* that encodes the dependency of *he* on *a man*.

-The *E-type analysis* must address two challenges. (i) First, it must explain which man the pronoun *he* (analyzed as meaning *the man*) refers to in (5)a – for there is certainly more than one man in the world. The standard solution is to take the word *if* to make reference to 'situations' that are small enough to contain just one man. *If a man drinks, he suffers* is thus analyzed as: *In every situation s in which a man drinks, the man in s suffers,* with one man per situation. (ii) Second, the classical analysis must explain what kind of formal link connects *he* to *someone* in (5)a. While the thrust of the approach is that this link is not directly interpreted (or else the analysis would be granting the main point of the dynamic solution), there appears to be some formal connection between the pronoun and its antecedent, which forces the latter to be a noun phrase. The motivation for this conclusion is that when one keeps the meaning of the *if*-clause constant, it can be shown that the presence of a noun phrase is crucial to license the pronoun. For instance, *John is married* and *John has a wife* are usually synonymous; but although (7)a is grammatical, (7)b is not – it seems that the pronoun is missing a noun phrase as its antecedent.

(7)   a. If John had a wife, he would be kind to her.
       b. #If John were married, he would be kind to her.

This is known as the problem of the 'formal link' between the pronoun and its antecedent (Heim 1990). While different E-type theories give different solutions to this problem, we will follow here Elbourne's elegant analysis (Elbourne 2005): the desired data can be derived if *her* is represented as *the* ~~wife~~, with ellipsis of *wife*, which must be recovered through a syntactic operation; ellipsis resolution can in effect establish the desired formal link between *she* and its antecedent.

In Schlenker 2011a,c, ASL and LSF data were used to suggest that:

(i) dynamic approaches predict the correct indexing patterns in the case of donkey sentences;

(ii) E-type approaches in general, and Elbourne's analysis in particular, are faced with a dilemma: either they are refuted by our sign language data, or they must be brought so close to dynamic semantics that they might end up becoming a variant of it.

One of the focal points of the debate has concerned so-called 'bishop' sentences, which are characterized by the fact that two pronouns are dependent on non-commanding indefinite antecedents with symmetric semantic roles, as in (8)a.

(8) a. If a bishop meets a bishop, he blesses him.
   b. If [a bishop]$_x$ meets [a bishop]$_y$, he$_x$ blesses him$_y$.
   c. If [a bishop] meets [a bishop], he ~~bishop~~ blesses him ~~bishop~~.
   c'. If [a bishop] meets [a bishop], he ~~bishop #1~~ blesses him ~~bishop #2~~.

The 'bishop' sentence in (8)a is crucial because the situations referred to by the *if*-clause include two bishops that play symmetric roles (if a bishop x meets a bishop y, it is also true that a bishop y meets a bishop x). The *dynamic analysis* in (8)b has no difficulty here because each noun phrase introduces a separate variable; this allows each pronoun to depend on a different quantifier because he$_x$ and him$_y$ carry different variables (we could also have he$_y$/him$_x$, but not he$_x$/him$_x$ or he$_y$/him$_y$: the pronouns must carry different variables to refer to different bishops, or else the sentence would be understood as involving self-blessings – and in addition a reflexive would be needed). The *E-type analysis* must first postulate that the two bishops mentioned in the antecedent of (8)a are in principle distinguishable by some descriptions. This is not quite trivial: if bishop b meets bishop b', by virtue of the (symmetric) meaning of *meet*, it is also the case that bishop b' meets bishop b. In the theory developed in Elbourne 2005, the *if*-clause is taken to quantify over extremely fine-grained situations – so fine-grained, in fact, that a situation <x, y, meet> in which x meets y is different from a situation <y, x, meet> in which y meets x. But this is not quite enough: to obtain the right meaning the pronouns must still be endowed with some additional material – perhaps provided by the context – to pick out different bishops in a given case <bishop$_1$, bishop$_2$, meet>. (8)c is thus insufficient because it does not specify *which* bishop each pronoun refers to; in (8)c', the pronouns are enriched with the (stipulated) symbols *#1* vs. *#2*, which are intended to pick out the 'first' or the 'second' bishop in <bishop$_1$, bishop$_2$, meet>. But the question is how these index-like objects end up in the Logical Form. For Elbourne's theory, the dilemma is as follows:

Horn I. If *#1* and *#2* are provided by a mechanism – possibly a contextual one – which is independent from NP ellipsis resolution, we make the counterintuitive prediction that the two pronouns can be dependent on the same quantifier *while still carrying different index-like objects*. Importantly, this is so while we keep the intended meaning constant, a meaning that involves one bishop blessing *the other* bishop (no self-blessings, here!). The reason for the counterintuitive prediction is that the role of distinguishing the two bishops falls on the symbols *#1* and *#2*, which are provided independently of the ellipsis resolution process by which pronouns are formally linked to their antecedents. So long as ellipsis provides the right NP(just *bishop* in (7)a), and *no matter where this NP is obtained,* the right truth conditions will be produced.

Horn II. If *#1* and *#2* are inherited by the mechanism of ellipsis resolution itself, we will end up with something very close to a dynamic analysis: the antecedents carry a formal index, and the pronouns recover the very index carried by their antecedent, as is illustrated in (9):

(9) If [a bishop]#1 meets [a bishop]#2, he ~~bishop #1~~ blesses him ~~bishop #2~~.

The innovation of the analysis is in essence to *add* a story about ellipsis to a dynamic-style account, but it's not clear at all that the latter has been *replaced* with a classical account.

For spoken languages, one might well want to choose Horn I of the dilemma – after all, *he* and *him* in (7)a do not wear their antecedents on their sleeves, hence the counterintuitive prediction (namely that the two pronouns could go back to the same antecedent *while still yielding the intended meaning*) is just this, counterintuitive. But things are different in ASL (and LSF): there it is clear that the only way to obtain the intended reading is to ensure that the pronouns index different antecedent. This is shown in a structurally related example in (10) (it is a bit more complex than (8)a because we

wanted to display a sentence that does not involve a 'Condition B' configuration in which the second pronoun is locally c-commanded by the first; in the end this point is immaterial, since in any event the intended reading does not involve coference between the two pronouns, and hence shouldn't yield a Condition B effect in the first place).

(10) WHEN ₐ[FRENCH MAN] a,b-MEET ᵦ[FRENCH MAN],
    'When a Frenchman meets a Frenchman,'
    a. IX-a WONDER WHO IX-b LIVE WITH.
    'the former wonders who the latter lives with.'
    b. ? IX-b WONDER WHO IX-a LIVE WITH.
    'the latter wonders who the former lives with.'
    c. # IX-a WONDER WHO IX-a LIVE WITH.
    'the former wonders who the former lives with.'
    d. # IX-b WONDER WHO IX-b LIVE WITH.
    'the latter wonders who the latter lives with.'

Our sign language data do not refute all E-type analyses; in fact, it has been repeatedly argued in the literature that some E-type accounts are notational variants of dynamic accounts (Dekker 2004). But they suggest that there is overt motivation for the main ingredients of the dynamic analysis:
(i) A sign language locus appears to play very much the role of a formal index, which is carried by a pronoun *and* by the antecedent it is anaphoric to.
(ii) Just as is the case with loci, the formal relation which is mediated by dynamic indices is not constrained by c-command.
(iii) The semantics of indices and quantifiers guarantees that two indices introduced by different quantifiers can 'refer' (under an assignment function) to different individuals; the fact that two pronouns carry the same or different variables will thus have a direct semantic reflex, as is desired.

4   Iconic Variables

The preceding paragraphs were concerned with two classic semantic debates that can be illuminated by sign language data. We turn to a property of sign language anaphora that arguably requires a *modification* of the frameworks typically used by formal semanticists.

Iconic effects are known to be pervasive in sign language. To see an intuitively clear example, consider the verb *GROW* in (11), which can be realized in a variety of ways, six of which were tested in (12).

(11) POSS-1 GROUP GROW.
    'My group has been growing.'

(12) Representation of *GROW*

	Narrow endpoints	Medium endpoints	Broad endpoints
Slow movement	small amount, slowly	medium amount, slowly	large amount, slowly
Fast movement	small amount, quickly	medium amount, quickly	large amount, quickly

The sign for *GROW* in (11) starts out with the two hands forming a sphere, with the closed fist of the right hand inside the hemisphere formed by the left hand; the two fists then move away from each other on a horizontal plane (simultaneously, the configuration of the right hand changes from closed to open position). The signer varied two main parameters in (12): the distance between the endpoints; and the speed with which they were reached. All variants were entirely acceptable, but yielded different meanings, as indicated in (12). Intuitively, there is mapping between the physical properties of the sign and the event denoted: the broader the endpoints, the larger the final size of the group; the more rapid the movement, the quicker the growth process.

Such effects are pervasive in sign language. In Schlenker 2012 and Schlenker et al. 2012, we asked (i) how they interact with the representation and interpretation of variables; and (ii) how this interaction should be modeled. Our main claim is that sign language loci are simultaneously variables and pictorial representations: their values are provided by assignment functions, but the interpretation

function is constrained to preserve some geometric properties of signs, and thus it has an iconic component. In effect, our attempt has been to reconcile two camps in sign language research. The 'formalist camp' (e.g. Lillo-Martin and Klima 1990, Neidle et al. 2000, Sandler and Lillo-Martin 2006) emphasizes the importance of predictive formal models, but so far it has had relatively little to say about iconic considerations. The 'iconic camp' (e.g. Cuxac 1999, Taub 2001, Liddell 2003) emphasizes the importance of iconic conditions, but does so within frameworks that are considered insufficiently explicit by the formalist side. We claim that some of the insights of the iconic camp are essential for a proper understanding of the semantics of sign language variables; but that understanding requires the kind of formal frameworks espoused by formalists – hence the necessity to incorporate to the latter an explicit iconic component.

Specifically, we argue that expressions that have a pronominal component in sign language (pronouns and their associated 'loci', and also agreement verbs) sometimes involve *iconic variables,* i.e. symbolic expressions that are *both* logical variables and simplified pictures of what they denote. We make our case on the basis of three phenomena: (i) *structural iconicity*, where relations of inclusion and complementation among loci are directly reflected in their denotations; (ii) *locus-external iconicity*, where the high or low position of a locus in signing space has a direct semantic reflex, akin to the semantic contribution of gender features of pronouns; and (iii) *locus-internal iconicity*, where different parts of a structured locus are targeted by different agreement verbs, as was argued by Liddell 2003 and Kegl 2004. In terms of semantic implementation, the key idea ('formal iconicity') is that some geometric properties of signs in general, and of variables in particular, must be preserved by the interpretation function.

4.1   Structural Iconicity

The simplest instance of an iconic constraint concerns plural ASL and LSF loci, which are usually realized as circular areas. These can be embedded within each other, and we hypothesize that this gives rise to cases of *structural iconicity,* whereby topological relations of inclusion and relative complementation in signing space are mapped into mereological analogues in the space of loci denotations.

Our initial focus was on 'complement set anaphora', illustrated for spoken language in (13):

(13)   ?Few / #Most students came to class. They [*intended*: the students who didn't come] stayed home instead.

This anaphoric pattern, whereby *they* in (13) is read as referring to the students that did *not* come, is at best limited with *few* and nearly impossible with *most;* Nouwen 2003 argues that when available, complement set anaphora involves *inferred* discourse referents: no grammatical mechanism makes available a discourse referent denoting the complement set – here: the set of students who *didn't* come; by contrast, a discourse referent does denote the students that *did* come, as in the sentence: *Few / Most students came to class. They* [*intended*: the students who came] *asked good questions.*

On the basis of ASL and LSF data, we made two main observations.

Observation I. When a default plural locus is used in ASL, data similar to (13) can be replicated – e.g. complement set anaphora with *most* is quite degraded. This is illustrated in (14), with average judgments (per trial) on a 7-point scale, with a total of 5 trials and 3 informants.

(14) POSS-1 STUDENT FEW a-CAME CLASS.   POSS-1 STUDENT MOST a-CAME CLASS.
     3.6 IX-arc-a a-STAY HOME   2.8 IX-arc-a a-STAY HOME
     Intended: 'Few/Most of my students came to class. They [the students that didn't come] stayed home.'

Observation II. When embedded loci are used, the effect is circumvented: one large locus (written as *ab*, but signed as a single circular locus) denotes the set of all students; a sub-locus (= *a*) denotes the set of students who came; and a complement locus (= *b*) thereby becomes available, denoting the set of students who didn't come, as illustrated in (15) and (16).

(15)
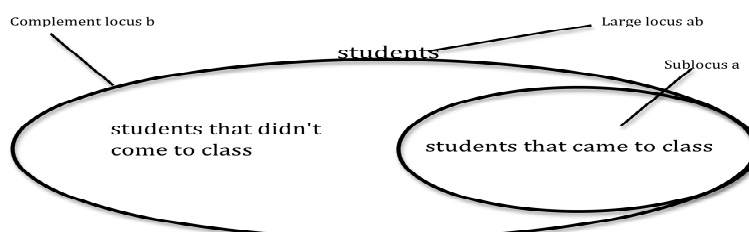
(16) a. 6.7 POSS-1 STUDENT IX-arc-ab FEW   b. 6.3 POSS-1 STUDENT IX-arc-ab MOST
      IX-arc-a a-CAME. IX-arc-b b-STAY HOME   IX-arc-a a-CAME. IX-arc-b b-STAY HOME
      'Few of my students came. They [= the ones who   'Most of my students came. They [= the ones
      didn't come] stayed home.'   who didn't come'] stayed home.'

We account for Observation I and Observation II by assuming that (i) Nouwen is right that in English, *as well as ASL and LSF*, the grammar *fails* to make available a discourse referent for the complement set, i.e. the set of students who didn't come; but (ii) the mapping between plural loci and mereological sums preserves relations of inclusion and complementation, which in (16) makes available the locus b. The main assumptions for us are that (a) the set of loci is closed with respect to relative complementation: if a is a sublocus of b, then *(b-a)* is a locus as well; and (b) assignment functions are constrained to respect inclusion and relative complementation: if a is a sublocus of b, the denotation of a is a subpart of the denotation of b, and *(b-a)* denotes the expected complement set. These conditions are stated more completely in (17):

(17) Conditions of loci
    Let LOC be the set of plural loci that appear in signing space, and let s an admissible assignment function that assigns values to loci. We make the assumptions in (a)-(b), where we view plural loci as sets of geometric points, and loci denotations as sets of individuals.
    a. Conditions on LOC: for all a, b $\in$ LOC, (i) a $\subseteq$ b or b $\subseteq$ a or a $\cap$ b = $\emptyset$; (ii) if a $\subset$ b, (b-a) $\in$ LOC
    b. Conditions on s: for all a, b $\in$ LOC, (i) a $\subset$ b iff s(a) $\subset$ s(b); (ii) if a $\subset$ b, s(b-a) = s(b)-s(a)

In (15)-(16), where embedded loci are used, we can make the following reasoning:
–Since a is a proper sublocus of a large locus ab, we can infer by (17)a(ii) that *(ab-a)* (i.e. b) is a locus as well;
–by (17)b(i), we can infer that s(a) $\subset$ s(ab);
–and by (17)b(ii), we can infer that s(b) = s(ab)-s(a).
In this way, complement set anaphora becomes available because ASL/LSF can rely on an iconic property which is inapplicable in English. But this does not mean that there is an independent grammatical difference between these languages: as we saw, with default loci the English data are replicated, which suggests that Nouwen's assumption that the grammar does not make available a discourse referent for the complement set applies to sign language too. Rather, it is because of structural iconicity, not grammar in a narrow sense, that a difference does arise in the case of embedded loci.

4.2 Locus-external iconicity

Under restricted conditions, loci can be introduced high or low in signing space to refer to entities that are tall/powerful/important or short. Importantly, the relevant inferences are preserved with pronouns embedded under negation; for this reason, we treat these inferences as presuppositions. An ASL example is given in (18):

(18)   YESTERDAY IX-1 SEE R [= body-anchored proper name]. IX-1 NOT UNDERSTAND IX-a$^{\text{high / normal / low.}}$

    Inferences: high locus – R is tall, or powerful/important; normal locus: nothing special; low locus: R is short
        In Schlenker et al. 2012, we take height specifications to have the same kind of presuppositional semantics as gender features (Cooper 1983), but with an iconic component, as seen in (19) (the crucial presupposition is in bold).

(19) Presuppositions introduced by high loci
    Let c be a context of speech, s an assignment function and w a world (c_w = world of c). If i is a locus, n is a locus with neutral height, h is a measure of the heights of loci in signing space, $h_c(c_w)$ is a measure of height denotations in c_w given by the context c, and $\alpha_c > 0$ is a parameter given by the context c. Then:
    $[[\text{IX-i}]]^{c, s, w}$ = # iff s(i) = # or **|i - n| $\neq$ 0 and $h_c(\boxed{c_w})(s(i)) - h_c(\boxed{c_w})(s(n)) \neq \alpha_c(h(i) - h(n))$.** If $[[\text{IX-i}]]^{c, s, w} \neq$ #,
    $[[\text{IX-i}]]^{c, s, w}$ = s(i).

The part in bold requires that the height difference between the denotations in c_w of s(i) and s(n) be proportional to the height difference between the loci i and n, with a multiplicative parameter $\alpha_c > 0$.

Importantly, the height of denotations is assessed relative to the world c_w of the context: the presupposition is that sense indexical. This also seems to be the case of the presupposition triggered by *she* in English: in (20), the gender features of *she* can *only* interpreted *de re*, i.e. with respect to the context of the speech act rather than with respect to the world of evaluation.

(20) Bill wore a dress and make-up and John didn't realize that he was a man. He said that he/#she looked great and that he/#she was staring at him. (Sharvit 2008)

The indexical character of heigh specifications can be tested in ASL: in both (21)a-b, the height presupposition triggered by *IX-b^{high}* is satisfied with respect to my cousin's beliefs, but only in (21)b is it satisfied with respect to the world c_w of the context c. For this reason, only (21)b is fully acceptable for our informant.

(21)   POSS-1 COUSIN IX-a (a) 3 WRONGLY THINK   (b) 7 KNOW
          POSS-1 YOUNG BROTHER TALL. IX-a THINK IX-b^{high} BASKETBALL PERSON.
          'My cousin (a) wrongly thinks (b) knows that my younger brother is tall. He thinks he is a basketaball
          player.' [JL 12.05.12] = what do we infer about the younger brother's (a) actual size/age, (b) size/age
          acccording to my cousin?   a) he is not tall; b) he is tall

Now it would in principle be possible to state a version of (19) that does not make reference to a geometric projection between the signing space and the world of the context; this would in particular be the case if our initial and informal characterization of the import of high loci were fully correct. But things turn out to be more subtle: even if the denoted person is tall, one might still have to use a normal or even a low locus if that person is in lying rather than in standing position. This is shown for ASL in (22), where three pronominal heights are tested in three separate conditions, involving a person in (a) standing, (b) sitting, or (c) lying position.

(22)   *Context:* People seek self-knowledge in the weirdest of situations.
          YESTERDAY VERY TALL PHILOSOPHER PERSON
          (a) CL-stand$_a$ (b) CL-sit$_a$ (c) CL-lie$_a$ PARK.
          SUDDENLY IX-a$^{high / normal / low}$ UNDERSTAND IX-a$^{high / normal / low}$ / SELF-a$^{high / normal / low}$
          'Yesterday a very tall philosopher was (a) standing (b) sitting (c) lying in the park. Suddenly he understood
          him / himself.' (See Schlenker et al. 2012 for detailed ratings for all conditions.)

Two pronouns were contrasted, the non-reflexive pronoun *IX-a* and the reflexive pronoun *SELF-a*. Both targeted three different heights: high, normal, low, as illustrated in (23)

(23) Rough position of the index and middle finger of the dominant hand and of the non-dominant hand in examples (22)
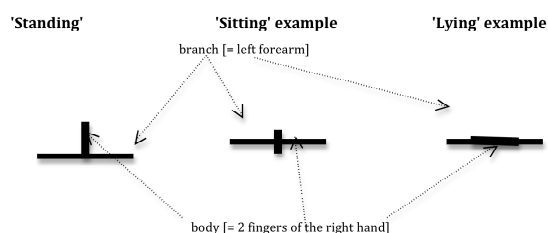
In all cases, *IX-a* was clearly dispreferred, as this is a configuration of local binding which requires a reflexive pronoun; this highlights the fact that *SELF-a* is a *bona fide* reflexive pronoun, whose syntactic behavior is reminiscent of its counterparts of spoken language (see Koulidobrova 2011 for a detailed discussion). Within the *SELF-a* examples, high loci were possible in the 'standing' condition, less so in the 'sitting' condition, and degraded in the 'lying' condition. In other words, *SELF-a* behaves in this case as a *bona fide* reflexive, but one that *also* has a strong iconic component – in other words, it is an 'iconic reflexive'.

4.3   *Locus-internal iconicity*

Agreement verbs are realized as movements that target one or several loci corresponding to their arguments. For instance, in LSF *1-TELL-2* 'I tell you' is realized as movement starting in the locus denoting the signer and ending in the locus denoting the addressee. Now despite many disagreements,

Liddell 2003 and Lillo-Martin and Meier 2011 agree that the effects of iconicity are felt with agreement verbs, which *target different parts of a locus depending on their meaning* – e.g. Liddell 2003 writes for instance that 'ASK-QUESTION^{-y} is directed toward the chin/neck area' of a locus, while 'COMMUNICATE-TELEPATHICALLY-1$^{[RECIP]-y}$...is directed toward the forehead'.

On an empirical level, we showed in Schlenker 2011b and Schlenker et al. 2012 that (i) Liddell's claims also hold of donkey and bound pronouns, and that (ii) the particular part of a locus which is targeted by agreement sometimes *depends on the position (upright or hanging) of the person referred to* (data in this latter respect are complex, and we can only scratch their surface here).

Let us consider first the issue of height differences across agreement verbs in LSF (ASL facts are similar, but the influence of body position seems to be a bit more subtle than in LSF). In (24), we contrast the agreement verbs 'communicate by telepathy' and 'exchange thoughts' with respect to the heights that they target: the former preferably targets a high locus; the latter an intermediate locus; ratings are averages per trial over two informants.

(24)   YESTERDAY LINGUIST$_b$ PHILOSOPHER$_a$ b,a-MEET.
   1. b,a-EXCHANGE   2. b,a-TELEPATHY
   'Yesterday, a linguist and a philosopher met. They 1. exchanged thoughts 2. communicated by telepathy.'
    a. High locus (1) 2 b^{high},a^{high}-EXCHANGE   (2) 6.4 b^{high},a^{high}- TELEPATHY
    b. Intermediate locus (1) 6.4 b^{medium},a^{medium}-EXCHANGE (2) 3 b^{medium},a^{medium} -TELEPATHY
    c. Low locus (1) 1.2 b^{low},a^{low}-EXCHANGE (2) 1b^{low},a^{low} -TELEPATHY

Turning to the second observation: in (26), a situation was described in which several individuals were either hanging from a branch or standing on a branch. In both cases, a horizontal movement of one hand represented the branch, while a vertical classifier represented the position of the body – with opposite orientations in the two conditions. The signer sought to ensure that the vertical space occupied by the ('hanging' or 'standing') person classifier was the same in the 'hanging' and in the 'standing' position, as is schematically represented in (25).

(25)

'Hanging'   'Standing'

position of branch

fingers = body
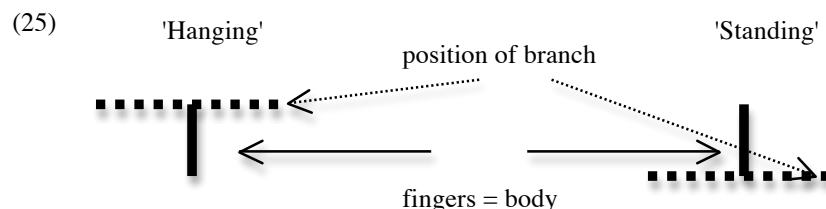
(26)   TREE BRANCH FRIEND POSS-1 SEVERAL   (1) HANG-rep (2) STAND-rep
   IX-a WANT IX-1 1-ASK-a$^{high / medium / low}$-rep.
   'Several of my friends were (1) hanging from (2) standing on a tree branch. One of them told me he wanted me to ask him questions.'
   a. High locus: 1-ASK-a^{high} (1) 2   (2) 5.5
   b. Intermediate locus: 1-ASK-a^{medium} (1) 6.5   (2) 3
   c. Low locus: 1-ASK-a$^{high / medium / low}$ (1) 2.5   (2)1

For each condition, there were three target heights that were tested for the agreement verb *ASK*: high, intermediate and low. As can be seen, the high locus is relatively acceptable in the 'standing' but not in the 'hanging' condition; for the intermediate locus, we obtain the opposite pattern. Thus the body position (standing or upside down) influences the choice of the point targeted by agreement verbs: there is a reversal of preferences across the two conditions.

A more direct argument for reversal is afforded by the sentence in (27): two agreement verbs targeting different heights, *TELEPATHY* ('communicate by telepathy' - high target in the 'standing' condition) and *EXCHANGE* ('exchange ideas' - intermediate target in the 'standing condition') appear in the same sentence, and three conditions were contrasted, with *TELEPATHY* targeting (a) a higher height than, or (b) the same height as, or (c) a lower height than *EXCHANGE*. Strikingly, in the 'hanging' condition in (27)1., (c) was preferred to (a)-(b); whereas in the standard control condition in

2. (involving a 'sitting' rather than 'standing' position, as in our earlier examples), (a) was preferred to (b)-(c).

(27)   YESTERDAY TREE BRANCH CL-_____$_b$ LINGUIST CL-_____$_a$ PHILOSOPHER.
                            neg_____
      a,b-EXCHANGE   a,b- TELEPATHY
      'Yesterday a linguist and a philosopher were hanging from / standing on a branch. They exchanged ideas but did not communicate by telepathy.'
      1. 'Hanging': _____ = hanging
   (a) 2 TELEPATHY > EXCHANGE   (b) 3.5 TELEPATHY = EXCHANGE (c) 6 TELEPATHY < EXCHANGE
      2. 'Standing': _____ = standing
      (a) 6 TELEPATHY > EXCHANGE (b) 3.5 TELEPATHY = EXCHANGE (c) 2 TELEPATHY < EXCHANGE

      We posit a presuppositional semantics for agreement verbs, but as in the case of pronouns we endow it with an explicit iconic requirement (in the cases we discuss here, these happen to hold both of the subject and of the object argument). To state it, we need to distinguish between *area loci,* which are structured (with a head and a foot) and receive a denotation from an assignment function; and *point loci,* which are parts of area loci that are targeted by agreement verbs. Now the iconic requirement makes crucial reference to the 'relative height' of a point locus within an area locus, measured *from the foot of the area locus*, as is illustrated in (28). The idea is that in the 'standing' condition, the verb *TELEPATHY* targets a higher point locus of the area locus than the verb *EXCHANGE* – i.e. a point which is closer to the top of the area locus. But for this reason, when an area locus is upside down because it denotes a person in hanging position (see (28)), the pattern is reversed, and *TELEPATHY* targets a lower point locus than *EXCHANGE*.

(28)   Constant relative height h of a point locus i relative to an area locus I despite changes of orientation (🐨 represents the 'head' position of the area locus; the opposite end is the foot position)
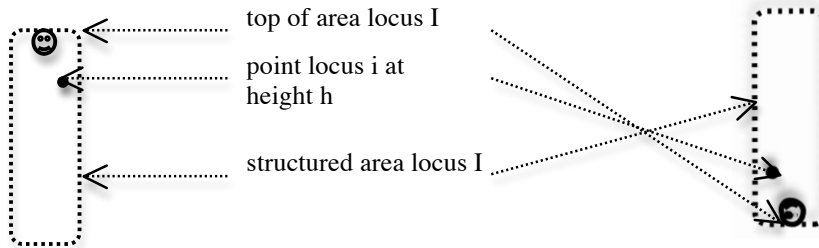
      In summary, we can now posit the lexical semantics in (29), where the iconic requirements appear in bold; the semantics is given for *ASK-QUESTIONS* but could be adapted to other agreement verbs, though of course they might be specified to target different parts of an area locus.

(29)   For any objects x and y of type e, for any context c, assignment function s, and world w, h is a measure of the heights of loci in signing space, h_c is a measure of height denotations given by the context c, and $\alpha_c > 0$ is a parameter given by the context c,
    $[[i\text{-ASK-QUESTIONS-j}]]^{c, s, w}(y)(x) = \#$ iff x = # or y = # or s(J) ≠ y or s(I) ≠ x or **the relative height of i within I is not roughly proportional to the relative height of the chin of s(I) within the body of s(I) in c_w, or the relative height of j within J is not roughly proportional to the relative height of the chin of s(J) within the body of s(J) in c_w.**
    If $[[i\text{-ASK-QUESTIONS-j}]]^{c, s, w}(y)(x) \neq \#$, $[[i\text{-ASK-QUESTIONS-j}]]^{c, s, w}(y)(x) = 1$ iff x ask questions to y in w.

In words: *i-ASK-QUESTIONS-j* is a movement from a point *i* of an area locus *I* to a point *j* of an area locus *J*; a failure is obtained unless *i* is with respect to *I* at the same relative height as the chin of s(I) with respect to the body of s(I); and similarly for *j, J*. This lexical entry can easily be adapted to the case of reciprocal verbs, for instance to *i,j-ASK-QUESTIONS* (with each locus appearing as the origin of the movement of one hand) rather than *i-ASK-QUESTIONS-j*. Importantly, the lexical entry in (29) only makes sense if the areas of space assigned as the value to capital letters are *oriented* – otherwise we couldn't speak *of the relative height of i within I*.

In the end, the analysis of iconic requirements should be connected to recent work on the formal semantics of gestures, for instance in Giorgiolo 2010, as well as to the formal semantics of pictures, as in Greenberg 2012; we leave this exploration for future research. Similarly, our discussion should in the future be connected to the very important work conducted by Wilbur (e.g. Wilbur 2003) on iconic-like effects in the semantics of aspect in ASL – effects that Wilbur crucially analyzes in a grammatical rather than in an iconic fashion.

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