Iconic Variables*

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Abstract. We argue that some sign language loci (i.e. positions in signing space that realize discourse referents) are *both* formal variables and simplified representations of what they denote; in other words, they are simultaneously logical symbols and pictorial representations. We develop a 'formal semantics with iconicity' that accounts for their dual life; the key idea ('formal iconicity') is that some geometric properties of signs must be preserved by the interpretation function. We analyze in these terms three kinds of iconic effects in American and French Sign Language (ASL and LSF): (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 directional verbs, as was argued by Liddell 2003 and Kegl 2004. The resulting semantics combines insights of two traditions that have been sharply divided by recent debates. In line with the 'formalist camp' (e.g. Lillo-Martin and Klima 1990, Neidle et al. 2000, Sandler and Lillo-Martin 2006), our theory treats loci as variables, and develops an explicit formal analysis of their behavior. But we also incorporate insights of the 'iconic camp', which emphasized the role of iconic constraints in sign language in general and in pronominals in particular (e.g. Cuxac 1999, Taub 2001, Liddell 2003). However, this synthesis is only possible if formal semantics makes provisions for iconic requirements at the very core of its interpretive procedure. (An Appendix discusses relevant data from Italian Sign Language [LIS].)

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1 Introduction: Logic and Iconicity

It is rather uncontroversial among sign language researchers that *iconic considerations* play an important role in the interpretation of the signed modality. It has also become increasingly clear (if still controversial) that the *logical system* that underlies sign language is highly similar to the one we find in spoken languages. Hence a natural question: *how do iconic considerations interact with logical grammar in sign language?* The field is rather sharply divided among two camps. 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 will seek to reconcile the insights of the two camps by developing the beginning of a *formal semantics with iconicity*. We focus on variables, which in one form or another are at the heart of most accounts of natural language semantics. We argue that expressions that have a pronominal component in sign language (pronouns and their associated 'loci', and also directional verbs) 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 that pertain to loci, i.e. positions in signing space that have been argued to the be overt realization of syntactic indices: (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 directional 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 variables in particular, must be preserved by the interpretation function.

1.1 Loci

In sign language, the relation between a pronoun and its antecedent is often mediated by *loci*. These are positions in signing space that can be introduced by noun phrases, and retrieved by pronouns (Sandler and Lillo-Martin 2006). Thus in (1)a, $BUSH_a$ and $OBAMA_b$ establish a locus by virtue of being signed in the corresponding position; in (1)b, the signs for *former senator* and *current senator* are immediately followed by the pointing signs *IX-a* and *IX-b* respectively, and these to establish the initial loci *a* and *b,* which are then retrieved by the pronouns (also signed as pointing signs *IX-a* and *IX-b*) which appear in the second sentence:[1]

(1) a. IX-1 KNOW $BUSH_a$ IX-1 KNOW $OBAMA_b$. 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. IX-1 KNOW [PAST SENATOR PERSON] IX-a IX-1 KNOW [NOW SENATOR PERSON] IX-b. 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.' (4, 179)

Since there appears to be an arbitrary number of possible loci, it was suggested that loci do not spell out morpho-syntactic features, but rather are the overt realization of formal indices (Lillo-Martin and Klima 1990, Sandler and Lillo-Martin 2006). While pointing can have a variety of uses in sign language (Sandler and Lillo-Martin 2006, Schlenker 2011a), we will restrict attention to pronominal uses. Importantly, there are some striking similarities between sign language pronouns and their spoken counterparts – which makes it desirable to offer a unified theory:
– Sign language pronouns obey at least some of the syntactic constraints on binding studied in syntax. For instance, versions of the following rules have been described for ASL (Lilla-Martin 1991, Sandler and Lillo-Martin 2006, Koulidobrova 2011): Condition A; Condition B; Strong Crossover.

[1] ASL sentences are glossed in capital letters. Subscripts correspond to the establishment of positions ('loci') in signing space. Pronouns are usually realized through pointing ('indexing') towards a locus, and they are also glossed as *IX-a*, *IX-b*, etc. Further information about glossing conventions is given in Section 1.3.2.

–In simple cases, the same ambiguity between strict and bound variable readings is found in both modalities (see Lillo-Martin and Sandler 2006):

(2) IX-1 POSS-1 MOTHER LIKE. IX-a SAME-1,a.
Ambiguous: I like my mother. He does too [= like my / like his mother] (1, 108)

–Similarly, the same cases of 'donkey anaphora', or apparent binding without c-command, are found in sign and in spoken language (Schlenker 2011b).

It is thus a reasonable hypothesis that the pronominal systems of sign and spoken language share at least a common core. As we will see, however, there are iconic effects in sign language pronominals, and these do not appear to have a counterpart in spoken language – hence a challenge for existing theories.

1.2 Iconicity

But what do we mean by 'iconic effects'? To see an intuitively clear example outside the realm of pronominals, consider the verb *GROW* in (3), which can be realized in a variety of ways, six of which were tested in (4).

(3) POSS-1 GROUP GROW.
'My group has been growing.' (8, 263; 264)

(4) 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 (3) 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 hemispheres 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 (4): the distance between the endpoints; and the speed with which they were reached.[2] All variants were entirely acceptable, but yielded different meanings, as shown in (4). 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.[3] Such effects are pervasive in sign language; we will ask (i) how they interact with the representation and interpretation of variables; and (ii) how this interaction should be modeled within a formal semantic analysis. 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 – hence an iconic component.

1.3 Languages and Methods

1.3.1 Languages investigated

Our data were initially investigated in ASL, and were then extended to LSF and LIS; for practical reasons, we only sought to replicate the main facts in LSF (in one case, involving directional verbs, our LSF data are in fact clearer than their ASL counterparts); Appendix I discusses a preliminary extension to LIS. ASL, LSF and LIS are closely related: ASL and LSF are both descended from Old French Sign Language (Shaw and Delaporte 2010); they are not inter-comprehensible, but they share important grammatical and lexical features. LIS and LSF are largely inter-comprehensible – and it is

[2] The paradigm was not fully minimal, in the sense that further aspects of the sign tended to be modified as well.
[3] Wilbur 2003 explored broadly 'iconic' ideas in her ground-breaking analysis of aspect. Crucially, however, she takes iconicity *not* to be a primitive linguistic condition; rather, according to her analysis sign language just happens to make *visible* certain (discrete, non-iconic) primitives for which there is independent evidence in spoken language. We come back to this point in the conclusion.

widely believed that they have a recent common ancestor.[4] Studying these three languages in parallel makes it possible to assess the *robustness* – or lack thereof – of the phenomena under study, while keeping the examples very similar across the three languages.

1.3.2 Elicitation: the 'Playback Method'

Before we introduce our findings, we should say a word about our elicitation method. It involved three steps.
(i) First, we elicited sentences of interest with a deaf native signer (Deaf child of Deaf, signing parents). Our emphasis was on the construction of controlled paradigms, usually of two to four sentences. All examples were videotaped.
(ii) Second, we showed the resulting videos to the same signer. For all crucial data, we asked the informant to rate the sentences on a 7-point scale.
(iii) Step (ii) was usually repeated several times, often on separate days, in order to assess the stability of our consultant's judgments. In several cases (mentioned in the text), Step (ii) was repeated with further native signers; they too were asked to provide judgments on a 7-point scale.

For ASL, unless otherwise noted the judgments given are those of co-author Jon Lamberton[5]. ASL judgments usually involved several iterations of the ratings, often on separate days. For LSF, data were provided by two native signers (Deaf children of Deaf, signing parents). Full ratings and further details appear in Appendix III. In the text, ratings on our 7-point scale are provided in lieu of the standard symbols used by linguists (*, *?, ??, etc.), with 7 = best and 1 = worst; when there were different numbers of trials per informant, the first rating gives equal weight to all trials, and the second rating [in square brackets] gives equal weight to all informants. Thus *3.6 [3.56]* right before a sentence means that the average rating across trials was 3.6, and across informants 3.56. (While the present piece is emphatically not an experimental paper, we hope that our methods could pave the way for an experimental study if and when necessary.)

In the following, sign language sentences are glossed in capital letters. Non-manual markings are omitted. Subscripts correspond to the establishment of locations ('loci') in signing space. Letters are assigned from right to left from the signer's perspective. 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, as discussed in connection to (1)b above, indexes can also be used to *establish* a locus). *IX-arc-a* refers to a plural pronoun indexing locus *a,* and *-rep* is used when a sign is repeated. An expression which is signed in locus *a* is signed with *a* as a subscript; this is in particular the case of classifiers, e.g. CL_a stands for a classifier signed in locus *a*. When an expression indexes a default locus, we write it without a letter index (e.g. *IX* rather than *IX-a*). Specifications are added to distinguish different classifiers – e.g. *CL-hang* stands for a classifier denoting a person in hanging position.[6]

2 Structural Iconicity in Plurals: Complement Set Readings[7]

Iconicity is sometimes defined as a pre-theoretical resemblance between a sign and what it denotes. Within a formal analysis, by contrast, we will take iconicity (henceforth 'formal iconicity') to refer to

[4] To our knowledge, there isn't much literature on this point. Carlo Geraci (p.c.) tells us that the standard assumption is that Abbé Silvestri went to Paris and learned from Abbé de l'Epée his teaching methods, which he brought back with him to Italy. The historical connection to French sign language is made on http://it.wikipedia.org/wiki/Lingua_dei_segni_italiana, and it seems to be taken for granted by signers who know both languages.

[5] Further judgments from two additional ASL native signers were obtained for some of the crucial data in Section 2.

[6] Lists of numbers following the examples are the references of the relevant videos (with the format folder, video; folder, video; etc.). For instance, *8, 198; 8, 199; 8, 204; 8, 222* refers to the original video in which the paradigm was recorded (video *8, 198*), followed by the references of three videos in which judgments were collected (they were simultaneously – and redundantly – entered into a computer). When the folder is the same for several videos, we often do not repeat it, writing for instance *8, 198; 199* for *8, 198; 8, 199*.

[7] This section borrows much material from Schlenker 2012 and Schlenker and Lamberton 2012. The LSF/LIS data and the inferential data on ASL are new, however (see Appendix I for the LIS data).

the *preservation of certain geometric properties of signs by the interpretation* – which need not always entail 'resemblance' in an intuitive sense. Thus we will have to specify three things: (i) which geometric properties of the signs are relevant to the effect; (ii) which properties of denotations they are mapped to; (iii) what is the nature of the mapping process. We start with an iconic effect in sign language plurals, which has the advantage of being relatively simple to analyze along these three dimensions (cases we study later are harder to formalize).

Our starting point is a traditional problem in semantics: the availability of 'complement set' readings in examples such as (5)a. We argue that this option is highly restricted in English, but fully available in ASL *when* the signer makes use of 'structural iconicity' to ensure that a locus can denote the so-called complement set, to be introduced shortly.

(5) a. *Complement Set Anaphora:* (i) ?Few / (ii) #Most students came to class. They stayed home instead.
b. *Maximal Set Anaphora:* (i) Few / (ii) Most students came to class, (i) but / (ii) and they asked good questions.
c. *Restrictor Set Anaphora:* (i) Few / (ii) Most students came to class. They (i) aren't / (ii) are a serious group.

Recent dynamic approaches to anaphora are designed to account for cases of 'maximal set' anaphora as in (5)b, where a pronoun refers to the maximal group of individuals that satisfy both the restrictor and the nuclear scope of a generalized quantifier. 'Restrictor set' anaphora, as in (5)c, is available as well: the plural pronoun just denotes the set of individuals that satisfy the restrictor. The question is whether complement set anaphora, as in (5)a, is genuinely available, and if so by what means. This option is notoriously restricted: it is often impossible with non-negative quantifiers, as in (5)a(ii); and some cases involving negative quantifiers can be re-analyzed in terms of a 'restrictor set' reading with a collective interpretation that tolerates exceptions. Following Nouwen 2003, we posit that when complement set anaphora is available it involves *inferred* discourse referents: no *grammatical* mechanism makes available a discourse referent denoting the complement set.

2.1 Complement set anaphora in ASL

2.1.1 Default loci

ASL signers can realize anaphora by different means. The first we consider involves a single default locus, realized in front of the signer. In this case, English-style judgments can be replicated with maximal set anaphora (= (6)a-b) and restrictor set anaphora (= (6)a'-b'). Crucially, this is also the case of complement set anaphora, which is quite degraded, as is seen in (7).

(6) a. 6.7 POSS-1 STUDENT FEW a-CAME CLASS.
'Few of my students came to class.'
IX-arc-a a-ASK-1 GOOD QUESTION
'They asked me good questions.'
a'. 6 POSS-1 STUDENT FEW a-CAME.
'Few of my students came.'

IX-arc-a NOT SERIOUS CLASS.
'They are not a serious class.'
(8, 198; 8, 199; 8, 204; 8, 222)

b. 6 POSS-1 STUDENT MOST a-CAME CLASS.
'Most of my students came to class.'
IX-arc-a a-ASK-1 GOOD QUESTION
'They asked me good questions.'
b'. 6.7 POSS-1 STUDENT IX-arc-a MOST a-CAME CLASS.
'Most of my students came to class.'
IX-arc-a SERIOUS CLASS.
'They are a serious class.'
(8, 200; 8, 201; 8 205; 8, 223)

(7) a. POSS-1 STUDENT FEW a-CAME CLASS.
3.6 [3.56] IX-arc-a a-STAY HOME
Intended: 'Few/Most of my students came to class. They [the students that didn't come] stayed home.'
(8, 225; 8, 226; 8, 285; 8, 300 I4; 8, 305; I5 8, 348)

b. POSS-1 STUDENT MOST a-CAME CLASS.
2.8 [2.67] IX-arc-a a-STAY HOME

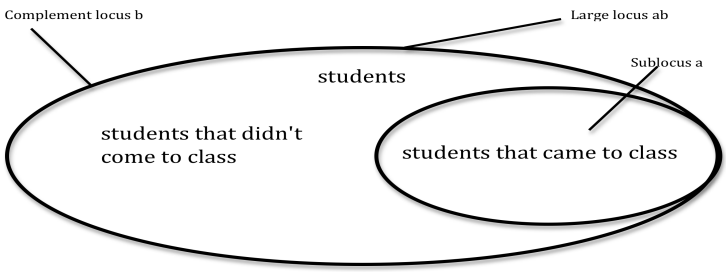
The high ratings in (6) were obtained from our main ASL consultant (as always, 1 = worst, 7 = best; average score over 3 iterations on separate days). The crucial data in (7) were tested with our main consultant (3 iterations) and 2 further consultants (1 iteration each), with clearly degraded ratings (1st score: equal weight for each trial; 2nd score: equal weight for each consultant).

2.1.2 Embedded loci

At this point, then, there appears to be no significant difference between the judgments obtained in our ASL examples and in their English sentences: in both cases, complement set readings are extremely restricted. However, another anaphoric strategy can be used in ASL. It consists in establishing a large plural locus *A* for the restrictor set [= the set of all students], and a sublocus *a* for the maximal set [= the set of students who came]. Specifically, a large circular area is signed with the index for *A,* and a small circular area within it (and towards its right) is signed for *a.* The complement locus *A-a* is indexed by pointing towards the area of *A* that doesn't overlap with *a.* Remarkably, this strategy automatically makes available a locus *A-a* for the complement set. Importantly, there is nothing here to suggest that this 'complement locus' was explicitly introduced: it seems to be made available solely by virtue of the geometric properties of space, which guarantee that if a subarea *a* of a larger area *A* has been made visible, the complement *A-a* thereby becomes visible as well. As a result, *all three readings become equally available*, though with different indexings (and importantly, all involve normal plural pronouns, and not the word *OTHER*). In (8), we provide our main consultant's judgments (3 iterations) based on this second anaphoric strategy ('embedded loci'). For perspicuity, we notate the large area *A* as *ab* to indicate that it comprises subloci *a* and *b* – although it is just signed as a large circular area, as is schematically represented in (9):

(8) POSS-1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME CLASS.
'Most of my students came to class.' (8, 196; 8, 197; 8, 206; 8, 224)
a. 7 IX-arc-b b-STAY HOME
'They stayed home.'
b. 7 IX-arc-a a-ASK-1 GOOD QUESTION
'They asked me good questions.'
c. 7 IX-arc-ab SERIOUS CLASS.
'They are a serious class.'

(9)



Data pertaining to complement set anaphora were also assessed in the same video as (7) (with the same 3 consultants); ratings confirm that with embedded loci complement set anaphora is acceptable ((10)b is similar to (8)a but was part of a different video):

(10) a. 6.7 [6.5] POSS-1 STUDENT IX-arc-ab FEW IX-arc-a a-CAME. IX-arc-b b-STAY HOME
'Few of my students came. They [= the ones who didn't come] stayed home.'
b.6.3[5.83] POSS-1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME. IX-arc-b b-STAY HOME
'Most of my students came. They [= the ones who didn't come'] stayed home.'
(In 1, 8, 225; 8, 226; 8, 285; 8, 300 I4; 8, 305; I5 8, 348)

2.2 Robustness of the phenomenon: extension to LSF

The main generalization can be extended LSF (see Appendix I for a discussion of LIS). First, we can replicate English-style judgments when a default locus is used, as in (11), where all three intended readings are tested (complement set, maximal set, restrictor set). Complement set anaphora is degraded, as seen in (11)a; maximal set anaphora is fine, as shown in (11)b. Restrictor set anaphora is

hard to assess in this case because (11)c might be interpreted as meaning that *all* the students together form a good class, or just the students who came; we take this example to be neutral in that respect.[8]

(11) STUDENT POSS-1 MOST IN CLASS.
'Most of my students are in class.' (22, 51; 52; 23, 7; 23, 22)
a. 2 [1.75] IX-arc HOME STAY.
'They stayed home.' (= the LSF version is contradictory, as is the translation)
b. 6 [6.25] IX-arc ASK-QUESTIONS GOOD.
'They asked good questions.'
c. 6 [6.25] IX-arc CLASS SERIOUS.
'They are a serious class.'

The facts change when the 'embedded loci' strategy is used instead: with the appropriate indexing, the complement set reading becomes fully available, as is seen in (12)a:

(12) STUDENT POSS-1 IX-arc-ab MOST_a IN CLASS.
'Most of my students are in class.' (22, 55; 57; 23, 9; 23, 24)
a. 6.33 [6.5]IX-b HOME STAY.
'They [= the students who aren't in class] stayed home.'
b. 6.3 [6.5] IX-arc-a ASK-QUESTIONS GOOD.
'They [= the students who are in class] ask good questions.'
c. 5.33 [5.75] IX-arc-ab GROUP SERIOUS.
'They [= the entire set of students] are a serious class.'

(12)c is slightly degraded, but this seems to be due to its semantic content: the discourse emphasizes at the same time that some students stayed home, and that the class is serious. When *SERIOUS* is replaced with *SERIOUS NOT*, the ratings improve:

(13) 6.33 [6.5] STUDENT POSS-1 IX-arc-ab MOST_a IN CLASS. IX-arc-ab GROUP SERIOUS NOT.
'Most of my students are in class. They are not a serious group.' (22, 59; 60; 23, 11; 23, 26)

Thus the main point we made for ASL appears to carry over to LSF: when a single default locus is used, complement set anaphora is unavailable; when embedded loci are used instead, complement set anaphora becomes fully available.

2.3 An analysis with structural iconicity

Our analysis has two components:
1. With respect to the grammar proper, we take ASL/LSF to be in this domain like English: in both cases, sentences with generalized quantifiers make available a discourse referent for the maximal set and another one for the restrictor set, but none for the complement set. The 'bare' grammatical mechanism is seen in ASL/LSF when default loci are used: for lack of a discourse referent denoting the complement set, the complement set reading is degraded.
2. Another mechanism, of a geometric nature, is responsible for making a third locus available in ASL/LSF when the maximal set locus *a* is embedded within the restrictor set locus *A*. The intuition we develop is that in this case (a) the geometry of loci guarantees that a third locus comes into existence, comprising roughly the area of *A* that's not in *a*, and (b) a condition of 'structural iconicity' guarantees that *(A-a)* gets the intended denotation. To put it more precisely: we hypothesize that assignment functions assign values to loci (Schlenker 2011a), and we further assume that:
(a) geometric properties of plural loci (*qua* areas of space) guarantee that if a locus *A* and a sublocus *a* have been introduced, a complement locus *(A-a)* thereby becomes available;

[8] The same concern could apply to (6)b', as was noted by an anonymous referee. But thanks to example (6)a', we can tell that restrictor set anaphora is possible: because of the presence of *FEW* in that example, the truth conditions obtained with maximal set anaphora (= *the students who came do not form a serious class*) are very distinct from those derived from restrictor set anaphora (= *the entire group of students does not form a serious class)*.

(b) relations of inclusion and relative complementation among loci are preserved by the interpretation function *via* constraints on assignment functions.

These assumptions are stated more precisely in (14).

(14) Let LOC be the set of plural loci that appear in signing space, and let s be an admissible assignment function that assigns values to loci. We view plural loci as sets of geometric points, and loci denotations as sets of individuals; we make the following assumptions:
a. *Constraints on LOC:* for all a, b ∈ LOC, (i) a ⊆ b or b ⊆ a or a ∩ b = Ø; (ii) if a ⊂ b, (b-a) ∈ LOC
b. *Constraints on s:* for all a, b ∈ LOC, if a ⊂ b, (i) s(a) ⊂ s(b); (ii) s(b-a) = s(b)-s(a)

In (5)-(10), we take the grammar to make available (i) a discourse referent for the maximal set and the restrictor set, but (ii) no discourse referent for the complement set (see Corblin 1996, Geurts 1997, Nouwen 2003). In this respect, the grammar of ASL/LSF is similar to the grammar of English as analyzed by Nouwen's (2003). For this reason, when a default locus is used, ASL/LSF roughly behaves like English, and complement set anaphora is highly restricted (because of (ii)). In case embedded loci are used, however, ASL/LSF allows for complement set anaphora. But this is not due to an essential grammatical difference between sign and spoken language. Rather, the constraints in (14) conspire to make available a locus that denotes the complement set. The reasoning is as follows:
–If *a* is a proper sublocus of a large locus *ab*, we can infer by (14)a(ii) that *(ab-a)* (i.e. *b*) is a locus as well.
–By (14)b(i), we can infer that s(a) ⊂ s(ab); and by (14)b(ii), that s(b) = s(ab)-s(a).
In other words, complement set anaphora becomes available in this case because ASL/LSF relies on an iconic property which is inapplicable in English; but this is the only grammatical that we must posit in this connection to account for the difference between English and ASL/LSF.

2.4 Inferential predictions for ASL

Before we go further, we should note that this analysis predicts that 'complement set' loci should denote *the entirety* of the complement set: this is specifically guaranteed by rule (14)b(ii). Other possible readings are conceivable; for instance, these loci might have turned out to denote a group which is *included* within the complement set (without being identical to it). The acceptability judgments we provided in Section 2.1.2 can't decide this fine-grained semantic prediction. We could obtain additional information on the examples in (8)-(10) by asking whether the subjects infer that *all* or that *some* of the students stayed home/asked good questions/form a serious class. But the difficulty is that collective interpretations of definite plurals typically allow for exceptions (e.g. Landman 1996), which will make the point hard to test. For instance, in the related examples in (15), the description *my students* presumably refers to the totality of the speaker's students, but inferential data are powerless to establish this fact because a collective interpretation might be true even if a couple of the relevant students fail to satisfy the relevant predicates.

(15) a. My students stayed home today
=> true if all of the speaker's students stayed home; but probably true as well if nearly all stayed home while a couple showed up in class
b. My students asked good questions
=> true if *all* of the speaker's students asked good questions, but also if *several but not all* asked good questions

The problem is addressed in a preliminary fashion (and for one ASL signer only) in (16), where the same predicate is used in all cases, and the addition of *ALL* guarantees that a reading 'with exceptions' is blocked. We obtain the expected inferences: in the complement set reading in (16)a, *IX-arc-b* refers to the entire set of students who didn't come, and for this reason the second sentence triggers the inference that *each* of them is independent-minded. Similarly, (16)b yields an inference that each of the students who came to class is independent-minded, and (16)c that all of the speaker's students are.

(16) POSS-1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME CLASS.
'Most of my students came to class.'
a. 7 IX-arc-b ALL INDEPENDENT-MINDED
Inference: all of my students who didn't come to class are independent-minded

'All of them [= the students who didn't come to class] are independent-minded.'
b. 7 IX-arc-a ALL INDEPENDENT-MINDED Judgment?
Inference: all of my students who came to class are independent-minded
'All of them [= the students who came to class] are independent-minded.'
c. 7 IX-arc-ab ALL INDEPENDENT-MINDED?
Inference: all of my students are independent-minded
'All of them [= the speaker's students] are independent-minded.' (10, 128; 129; 11, 5)

These inferential data thus confirm in preliminary fashion the analysis summarized in (14). More work would be needed to test our hypotheses in greater detail, of course.

At this point, then, we have seen a simple case of formal iconicity, one in which subset and complementation relations among loci are preserved by the interpretation function; this accounts for subtle differences between the anaphoric possibilities available for embedded loci on the one hand and default loci and English pronouns on the other. This instance of 'structural iconicity' has the advantage of being particularly transparent.

3 High loci and locus-external iconicity

We now turn to more subtle cases of iconicity. The first one concerns the vertical position of loci in signing space. High loci must refer to tall or important entities (people as well as more abstract entities, such as governments)[9]; low loci can be used to refer to short people, among others. We argue that this inference is a presupposition, formally analogous to that triggered by the gender features of pronouns; and we posit an iconic analysis that establishes a mapping between the height of the loci in signing space and the position of their denotata in the (real or metaphorical) world of the context.

3.1 Basic data and analysis

3.1.1 Basic data

To obtain an initial characterization of the semantic contribution of high and low loci, we asked our ASL consultant to imagine in what contexts the sentences in (17) could be uttered. These involve the body-anchored proper name *R* (e.g. for someone named *Robert*), which does not introduce an explicit locus in signing space; it is thus the pronoun that is responsible for specifying the height of the relevant locus. Importantly, we asked the consultant to provide acceptability judgments in the best context he could imagine for the sentence; this matters because the use of high or low loci in an 'out of the blue' context would normally yield deviance.

(17) YESTERDAY IX-1 SEE R [= body-anchored proper name]. IX-1 NOT UNDERSTAND IX-a$^{\text{high / normal / low}}$
'Yesterday I saw R [= body-anchored proper name]. I didn't understand him.' (11, 24; 25)
a. 7 High locus. *Inference:* R is tall, or powerful/important
b. 7 Normal locus. *Inference:* nothing special
c. 7 Low locus. *Inference:* R is short

Importantly, in (17) the inferences triggered by the height specifications of the locus are triggered within the scope of negation – and despite this they are inherited by the entire sentence (they 'project out'). This provides a preliminary motivation for treating these inferences as presuppositions, one of whose hallmarks is precisely that they project out of the scope of negation. Well-known instances of this behavior are shown in (18) with two standard presupposition triggers, the verb *stop* and the gender features of *her*.

(18) a. John hasn't stopped smoking => John used to smoke
b. I don't understand her => the person denoted by *her* is female

As seen in (17), the height of the denoted objects can justify the use of high and low loci, but this is not the only factor; for instance, power or importance can also trigger the use of high loci. This possibility is instantiated in (19)a and (20)a, where a high locus may be used to refer to the speaker's father or to the government.

[9] See Barberà 2012 for a very different use of high loci in Catalan Sign Language.

(19) a. 7 High locus: MY FATHER IX-a^{high} SELF-a^{high} BUSINESSMAN. IX-a^{high} RICH.
b. 5 Normal locus: MY FATHER IX-a BUSINESSMAN. IX-a RICH.
'My father is a businessman. He is rich.' (8, 17; 8, 18)

(20) a. 7 High locus: EACH ONE-arc GIVE-rep-a^{high} MONEY GOVERNMENT IX-a^{high}. IX-arc-a^{high} SHOULD RICH.
b. 5.5 Normal locus: EACH ONE IX-arc GIVE-rep-a MONEY IX-a GOVERNMENT. IX-arc-a SHOULD RICH.
'Everybody gives money to the government. They should be rich!' (8, 12; 8, 13)

It can be further checked that high and low loci can be used with variables bound by quantifiers – at least as long as the presupposition they trigger is satisfied within the restrictor of the quantifier:

(21) NO GIANT THINK IX-1 LIKE IX-a
'No giant thinks that I like him.' (11, 26; 11, 30; e12.07.24)
a. 6.5 High locus
b. 5.5 Normal locus
c. 2 Low locus

(22) NO TALL MAN THINK IX-1 LIKE IX-a
'No tall man thinks that I like him.' (11, 27; 11, 31; e12.07.24)
a. 7 High locus
b. 6 Normal locus
c. 3 Low locus

(23) NO DWARF THINK IX-1 LIKE IX-a
'No dwarf thinks that I like him.' (11, 28; 11, 32; e12.07.24)
a. 2 High locus
b. 6 Normal locus
c. 7 Low locus

Importantly, the sign for *GIANT* involves a very high position in signing space, and the sign for *DWARF* a low position. Thus one could imagine that the use of high and low loci is entirely conditioned by *morphological* properties of the antecedent (similarly, in (22), the word for *TALL* involves an upward movement of the index[10], and one might postulate that this suffices to establish a high locus). The paradigm in (24) excludes this possibility: the signer used a different word for *TALL*, one which is neither signed high nor pointing upwards[11]. This does not significantly change the judgments (especially when *VERY TALL* is used instead of *TALL*), which suggests that the correct generalization is semantic rather than morphological in nature (this conclusion will be further strengthened in Section 3.4.2).

(24) a. [EACH-rep TALL-rep MAN]$_a$ THINK NO ONE LIKE IX-a.
'Every tall man thinks that nobody likes him.'
1. 5 High locus
2. 7 Normal locus

b. [EACH-rep VERY TALL-rep MAN]$_a$ THINK NO ONE LIKE IX-a.
'Every very tall man thinks that nobody likes him.'
1. 6 High locus
2. 6 Normal locus

c. [EACH-rep GIANT-rep]$_a$ THINK NO ONE LIKE IX-a.
'Every giant thinks that nobody likes him.'
1. 6.5 High locus
2. 5.5 Normal locus
(8, 119; 8, 120)

[10] This sign can be seen here: http://www.signingsavvy.com/sign/TALL/2710/1
[11] In this sign, the two hands in 'Y' shape are connected by the thumbs, and move towards the signer.

3.1.2 A simple presuppositional analysis

Following Lillo-Martin and Klima 1990, we take sign language indexes to be, in the cases at hand, the overt realization of formal indices. Technically, we take assignment functions to assign values to loci as well as to standard (unpronounced) indices. We will take height specifications of loci to introduce a presupposition on the value of these variables.

To start with a more familiar framework, we give in (25)a a standard presuppositional analysis of feminine features on pronouns (Cooper 1983; Heim and Kratzer 1998). Our initial rule for height specifications is stated in a similar format in (25)b:

(25) Let c be a context of speech, w a world, and s be an assignment function (with c_a = the author of c; c_w = the world of c).

a. *Gender features*

If *f* is a feminine feature and *i* is in index,

$[[\text{pro-f}_i]]^{c,s,w} = \#$ iff s(i) = # or **s(i) is not female in the world of c**. If $[[\text{pro-f}_i]]^{c,s,w} \neq \#$, $[[\text{pro-f}_i]]^{c,s,w}$ = s(i).

b. *Height specifications* (1st try)

(i) If *i* is a locus that appears high in signing space, $[[\text{IX-i}]]^{c,s,w} = \#$ iff s(i) = # or **s(i) is not powerful, important or tall relative to c_a** in c_w. If $[[\text{IX-i}]]^{c,s,w} \neq \#$, $[[\text{IX-i}]]^{c,s,w}$ = s(i).

(ii) If *i* is a locus that appears low in signing space, $[[\text{IX-i}]]^{c,s,w} = \#$ iff s(i) = # or **s(i) is not short relative to c_a** in c_w. If $[[\text{IX-i}]]^{c,s,w} \neq \#$, $[[\text{IX-i}]]^{c,s,w}$ = s(i).

(25)a states that a pronoun with feminine features *pro-f_i* evaluated with respect to a context c, a world w and an assignment function s yields a presupposition failure, i.e. denotes #, in case the assignment s fails to assign to the formal index *i* an individual who is female in the world of the context c (we explain in Section 3.3 why we posit that gender is assessed with respect to c rather than w). If no failure arises, *pro-f_i* denotes s(i). An analogous rule is stated for high loci in (25)b(i): if *i* is a locus that appears high in signing space, a pronoun *IX-i* realized by a pointing sign towards locus *i* give rise to a presupposition failure unless s(i) is powerful, respectable or tall relative to the speaker in the world of c. And similarly for low loci in (25)b(ii), except that the presupposition solely concerns height (rather than power or importance), because this is all our limited data allow us to posit. Needless to say, further research would undoubtedly lead one to refine the particular content of these presuppositions; here we are primarily interested in the *form* of the lexical entries rather than in their specific content.

3.1.3 Presuppositional tests

Rule (25)b predicts that the inferences triggered by the height specifications of loci should be presuppositional. Partial evidence for this conclusion was provided by our very first example in (17), which showed that the relevant inferences can be triggered by pronouns in the scope of negation. Restricting attention to high loci, this point is also made by the pair in (26), where we see that the same inferences about the speaker's younger brother's height is obtained irrespective of the presence of a negation (the fact that we are talking about the speaker's younger brother makes it more likely that the inferences solely concern height rather than power, though other readings are conceivable as well).

(26) a. 6 POSS-1 YOUNG BROTHER WANT IX-1 REST. IX-1 UNDERSTAND IX-a^{high}
Inference: the speaker's younger brother is tall.
'My younger brother wants me to rest. I understand him.' (10, 41; 44)

b. 6 POSS-1 YOUNG BROTHER WANT IX-1 REST. IX-1 NOT UNDERSTAND IX-a^{high}
Inference: the speaker's younger brother is tall.
'My younger brother wants me to rest. I don't understand him.' (10, 42; 45)

A further test is provided by the antecedent of conditionals, which normally project presuppositions rather strongly. Here too, we can check that height inferences are preserved in these environments, despite the fact that they are not assertive:[12]

(27) 7 IX-1 LIKE POSS-2 BROTHER. IF IX-a^{high} BECOME BASKETBALL PLAYER, IX-1 HAPPY.
Inference: the speaker's younger brother is tall.
'I like your brother. If he becomes a basketball player, I'll be happy.' (10, 60; 61)

3.2 Robustness of the phenomenon: extension to LSF

Before we go further, it is worth noting that the data we discussed do not seem to be peculiar to ASL: they can be replicated in very similar form in LSF (see Appendix I for some data from LIS).

Consider first the interpretive effect produced by (28) in LSF (*JEAN* is body-anchored, and thus is not responsible for establishing a high or low locus itself):

(28) YESTERDAY IX-1 SEE JEAN. IX-1 LIKE IX-a$^{high\ /\ normal\ /\ low}$ NOT
'Yesterday I saw Jean. I didn't like him.' (21, 46; 47)
a. 6 High locus
Contexts in which the sentence is acceptable: contexts in which Jean is taller, older or more powerful than the speaker (the rating is given *for these contexts)*.
b. 7 Normal locus
c. 6 Low locus
Contexts in which the sentence is acceptable: contexts in which Jean is a child or is short (the rating is given *for these contexts)*.

Without special context, (28)a,c might seem deviant. But here we asked our consultant to actively imagine contexts in which the sentences would be acceptable, and to assess the sentence in these 'best' contexts. Importantly, in (28) the pronoun denoting Jean is, once again, in the scope of negation; the inferences triggered by high and low loci seem to 'project out' of the scope of negation – which is consistent with their presuppositional status.

It is not hard to find examples in which pronouns indexing high or low loci are bound by quantifiers, as is the case in (29)-(30):[13]

(29) GIANT EACH-rep$_a$ REGRET IX-arc-b NO LIKE IX-a.
'Every giant regrets that nobody likes him.' (22, 43; 46; 23, 3; 23, 20)
a. 5.67 [5] IX-a high
b. 5.67 [6] IX-a normal
c. 2.33 [3] IX-a low

(30) DWARF EACH-rep$_a$[14] REGRET IX-arc-b NO LIKE IX-a.
'Each dwarf regrets that nobody likes him.' (22, 45; 47; 23, 4; 23, 21)
a. 1.67 [1] IX-a high
b. 4.67 [3] IX-a normal
c. 6 [6] IX-a low

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[12] Our lexical entry in (25)b treats the contribution of high loci as indexical, for reasons laid out in Section 3.3.1. Does this *lack* of world dependency impinge on the test in (27)? Not really: if the contribution of high loci were not presuppositional but assertive, the meaning of the second sentence of (27) would be akin to: *If your brother is tall in the actual world and he later becomes a basketball player, I'll be happy,* from which it still does not follow that the addressee's brother is in fact tall. We would presumably obtain an implicature that there is an epistemic *possibility* that he is in fact tall. While it cannot be completely excluded that the inference we find is due to a strengthening of this implicature, the negation test in (26)a provides circumstantial evidence that the inference is in fact presuppositional.

[13] Note that these examples do not involve Role Shift, i.e. the process by which the context of the embedded clause is 'shifted' thanks to a rotation of the signer's body. We leave for future research an exploration of the interaction between Role Shift and height specifications of loci.

[14] The version of *EACH-rep* signed here differs from that of the preceding sentence in involving a continuous movement of the thumb rather than a literal repetition of *EACH*.

The LSF data we currently have mirror our ASL data concerning the use of high and low loci; they might be a bit less permissive for normal loci, but it is too early to tell.

3.3 The indexical nature of height presuppositions

3.3.1 Indexical tests

The lexical entries we gave for gender features and height specification of loci in (25) are indexical: in each case, the denotation of the relevant variable is constrained to have a certain property *in the world of the context* c rather than in world of evaluation w. This makes an important difference in intensional environments, as shown for gender features in (31):

(31) 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 embedded pronouns *he/#she* have the semantics of variables, and given the discourse they refer to the individual Bill. If the feminine features were interpreted with respect to the world of evaluation, we would obtain a 'de dicto' reading and *she* would be acceptable, contrary to fact. The data thus suggest that these features are interpreted with respect to the world of the actual context (of speech) rather than with respect to the worlds (or contexts) compatible with what John said.

We can apply similar tests to high loci – and given our data they yield analogous results. Thus in (32)a, the 'high locus' component of *IX-b* can apparently not be read *de dicto*, for if it were, the discourse should make perfect sense given the first sentence. The judgments can be explained if the 'high locus' component is obligatorily read *de re,* as is predicted by the indexical lexical entry in (25)b.

(32) POSS-1 COUSIN IX-a WRONGLY THINK POSS-1 YOUNG BROTHER TALL. IX-a THINK IX-b$^{high/normal}$ BASKETBALL PLAYER.
'My cousin wrongly thinks that my younger brother is tall. He thinks he is a basketaball player.' (10, 66; 67; 11, 11; 11, 79)
a. 3 High locus
b. 7 Normal locus

If *WRONGLY THINK* in (32) is replaced with *KNOW*, the sentence becomes acceptable with a high locus:

(33) POSS-1 COUSIN IX-a KNOW POSS-1 YOUNG BROTHER TALL. IX-a WRONGLY THINK IX-b$^{high/normal}$ BASKETBALL PLAYER. (10, 68; 69; 11, 12; 11, 80)
'My cousin knows that my younger brother is tall. He wrongly thinks he is a basketball player.'
a. 7 High locus
b. 7 Normal locus

This is as expected given our semantics: the first sentence of (33) is factive, unlike its counterpart in (32); as a result, it establishes that the brother is tall in the world of the context, which licenses the use of a high locus in the second sentence[15].

The indexical nature of the presupposition introduced by high loci is further highlighted by the deviance of (34)a:

(34) IF POSS-2 LITTLE BROTHER FUTURE BECOME TALL, IX-a$^{high/normal/low}$ SHOULD BECOME BASKETBALL PLAYER.
'If your little brother later becomes tall, he should become a basketball player.' (10, 64; 65; 11, 13)
a. 3 High locus
b. 6.5 Normal locus
c. 7 Low locus

[15] *WRONGLY* has been added to the second sentence of (33) to make it clear that, like its counterpart of (32), it reports a false belief.

The conditional sentence triggers the implicature that the addressee's brother is not currently tall, and for this reason the high locus in the consequent is not licensed. This is as expected if the semantic contribution of the high locus is interpreted indexically, and hence *de re*. By contrast, if this contribution were read *de dicto,* it *would* be licensed because of the content of the antecedent. (To provide a full formal treatment of this example, we would need to add a time parameter to our analysis, which we won't do here for reasons of simplicity).

3.3.2 A shared difficulty in the analysis of gender features and high loci

While appropriate for the examples we have seen so far, our indexical analysis of gender features encounters difficulties in more involved examples, such as (35):

(35) My students wrongly think that I have a sister, and they are convinced that she is basketball player.

The problem is that the first sentence establishes that the speaker has no sister, and hence it isn't clear what it means for the denotation of the pronoun to be female *in the actual world* (which individual is the pronoun supposed to denote in that world?). An analysis is needed to explain why this case allows for something more than the *de re* reading we posited for our earlier examples. Descriptively, it appears that when the antecedent of the pronoun has no existential import with respect to the actual world, the gender features of the pronoun can be interpreted with respect to counterfactual worlds. The analysis of this phenomenon is a matter of debate in the literature (see Yanovich 2010 and Sudo 2012 for recent discussions). Our goal is not to decide it, but simply to note that the same data and hence difficulties arise with high loci, as shown by (36) and (37); importantly, each 4-sentence set was signed on a single video, and judgments were thus obtained in a contrastive fashion.

(36) a. POSS-1 BROTHER SHORT BUT POSS-1 STUDENT IX-arc-a THINK POSS-1 BROTHER TALL. IX-arc-a THINK IX-a$^{high\ /\ normal}$ BASKETBALL PLAYER.
'My brother is short, but my students think my brother is tall. They think he is a basketball player.' (10, 81; 82; 96; 11, 14; 11, 22; 11, 81)
1. 4 High locus
2. 7 Normal locus
b. IX-1 HAVE NO BROTHER, BUT POSS-1 STUDENT IX-arc-a THINK IX-1 HAVE TALL BROTHER. IX-arc-a THINK IX-b$^{high\ /\ normal}$ BASKETBALL PLAYER.
'I have no brother, but my students think I have a tall brother. They think he is a basketball player.'
1.7 High locus
2. 5.8 Normal locus

The judgments in (36)a replicate the type of paradigm we saw in (32): a *de dicto* interpretation of the contribution of the high locus appears to be degraded. By contrast, when the antecedent has no existential import with respect to the actual world, the *de dicto* interpretation becomes available: in (36)b1, the 'high locus' component of *IX-b* is interpreted relative to the worlds compatible with respect to the students' beliefs. A similar conclusion can be reached – with less clear judgments – on the basis of the paradigm in (37) (note that the antecedent of the conditional involves a null pronoun; this is to avoid a situation in which the choice of locus in the antecedent might bias the position of the locus indexed by the pronoun).

(37) a. POSS-1 BROTHER SHORT, BUT IF TALL, IX-a$^{high\ /\ normal}$ WILL BASKETBALL PLAYER.
'My brother is short, but if he were tall, he would be a basketball player.' (10, 79; 80; 95; 11, 15; 11, 23; 11, 82)
1. 5.4 High locus
2. 6.6 Normal locus
b. IX-1 NO BROTHER, BUT IF BROTHER TALL, IX-a$^{high\ /\ normal}$ WILL BASKETBALL PLAYER.
'have no brother, but if I had a tall brother, he would be a basketball player.'
1. 6.8 High locus
2. 5.6 Normal locus

3.4 The iconic nature of height presuppositions

Up to this point, we have treated height specifications of loci as if they were arbitrary symbols. Here we show that the theory can, and maybe must, be recast within an iconic analysis in which some geometric properties of signs must be preserved by the interpretation function.

3.4.1 Restatement: a simple presuppositional analysis with iconicity

As stated, the rule in (25)b makes it an arbitrary fact that loci that appear high, rather than low or on the right, carry presuppositions that involve tallness and great power/importance. But intuitively this isn't an accident: in each case, a (real or metaphorical) projection seems to be established between the position of locus *i* relative to the signer, and the position of the denotation of *i* relative to the signer on some salient scale (of height, power or respectability).

As we noted at the beginning of Section 2, the formal analysis of an iconic effect must specify three things: (i) which geometric properties of the signs are relevant; (ii) which properties of denotations they are mapped to; (iii) what is the nature of the mapping process. We will explore the view that (i) the relation 'has a greater height than' among loci (written as >) is mapped to (ii) a salient relation given by the context c – often 'is taller than', or 'is more powerful than' (written as $>_c$) by (iii) the interpretation function. In other words, we assume that the context c makes salient an order $>_c$ (which could be partial) over loci denotations, and we avail ourselves of a natural ordering of loci by height, written as >. Next, we posit that a presupposition failure is obtained if locus i is either above or below a neutral locus n but the assignment function s does not preserve this ordering when > (= the height ordering over loci) is mapped to $>_c$ (= the ordering over locus denotations). This leads to the analysis in (38):

(38) *Height specifications* (2nd try)
Let c be a context of speech and s be an assignment function (with c_a = the author of c; c_w = the world of c).
If *i* is a locus, n is a locus with neutral height, > is the natural height ordering among loci, and $>_c$ is an ordering over loci denotations given by the context c,

$[[\text{IX-i}]]^{c,s,w}$ = # iff s(i) = # or **it is not the case that [(i > n ⇒ s(i) $>_c$ c_a in c_w) and (n > i ⇒ c_a $>_c$ s(i) in c_w)].**

If $[[\text{IX-i}]]^{c,s,w} \neq$ #, $[[\text{IX-i}]]^{c,s,w}$ = s(i).

For future reference, we note that this rule has the general format in (39), where n is a distinguished locus and i is the locus indexed by the pronoun; the nature of the 'iconic relation' R could of course take a variety of forms, but forces the interpretation function to preserve certain geometric properties of signs.

(39) ... $[[\text{IX-i}]]^{c,s,w}$ = # iff s(i) = # or **<n, i> does not stand in iconic relation R to <s(n), s(i)> in c_w**.
If $[[\text{IX-i}]]^{c,s,w} \neq$ #, $[[\text{IX-i}]]^{c,s,w}$ = s(i).

The new rule has the same general form as (25)b, except that one subcase of presupposition failure is explicitly connected to the failure of the assignment function s to preserve a height ordering over loci; this makes it possible to unify the two subcases of rule (25)b in a relatively natural fashion. The new rule also bears a family resemblance to the analysis of embedded loci we developed in Section 2. The difference is that there we assumed that admissible assignment functions preserve certain geometric properties of loci (those of inclusion and relative complementation), which in turn guaranteed the existence – and proper interpretation – of complement loci; here, by contrast, we posit a presupposition failure when the assignment function fails to respect the appropriate ordering. The difference is slight: we could have given a presuppositional statement of the conditions on plural loci in (14)b, while assuming that speech act participants are wise enough to choose assignment functions that satisfy these presuppositions. Thus the two analyses share a common core, namely the idea that semantic interpretation is sometimes constrained to preserve some geometric properties of signs.

Importantly, the new rule could be restated in the more conservative framework of Section 3.1.2, without explicit iconic provisions – for instance as in (40). (38) incorporated conditionals that forced the space of denotations to preserve the ordering of loci relative to a neutral position – e.g. the

conditional *(i > n ⇒ s(i) >$_c$ c_a in c_w)*. The notational variant in (40) has no such conditionals, but simply distinguishes cases as a traditional grammatical rule might:

(40) *Height specifications* (2nd try - conservative version)
Let c be a context of speech, s an assignment function and w a world (with c_a = the author of c; c_w = the world of c).
If *i* is a locus, n is a locus with neutral height, > is the natural height ordering among loci, and >$_c$ is an ordering (given by the context c) of objects according to their heights in c_w,
(i) If i > n, $[[IX\text{-}i]]^{c,s,w}$ = # iff s(i) = # or **it is not the case that s(i) >$_c$ c_a in c_w**. If$[[IX\text{-}i]]^{c,s,w} \neq$ #, $[[IX\text{-}i]]^{c,s,w}$ = s(i).
(ii) If n > i, $[[IX\text{-}i]]^{c,s,w}$ = # iff s(i) = # or **it is not the case that c_a >$_c$ s(i) in c_w**. If$[[IX\text{-}i]]^{c,s,w} \neq$ #, $[[IX\text{-}i]]^{c,s,w}$ = s(i).

Thus our argument is not that the iconic component is empirically necessary, just that it is a more insightful way to capture the phenomenon at hand (especially in view of the fact that other iconic rules can be stated within a similar format, for instance those we saw in Section 2).

Three remarks must be added.

–First, the rules in (38) and (25)b do not impose any condition on loci of normal height: given our current ASL data, it seems that these can denote objects irrespective of their height or importance (LSF data are less clear in this respect; see Appendix I for a brief discussion of LIS data). But more work is needed to establish the facts.

–Second, unlike (25)b, the rule in (38) (or its restatement in (40)) does not establish an asymmetry between high and low loci, with a broader range of meanings for the former (involving power/importance). We have no choice within the revised analysis (or its conservative restatement in (40)) but to blame the asymmetry on contextual factors, for instance on the fact that one might prefer to avoid situating people as somehow inferior to the signer (whereas presupposing that they are shorter is not as pragmatically loaded).

–Third, the rules in (38)-(40) only require that the ordering of loci *relative to a neutral locus n* be preserved in the space of denotations. In effect, this means that only three levels are meaningful. But of course it might be that more heights – or even a continuum – turns out to be necessary when further data are considered; we briefly reconsider this question in the next section.

3.4.2 Further data and refinements

Further specifications would be needed to determine what matters for the ordering of loci denotations. As mentioned, depending on the context the ordering may concern power/importance or height. In the latter case, we should further ask (i) what counts as the position of c_a, the agent of the speech act, and (ii) what counts as the position the denoted object. For future reference, we make the following assumption:

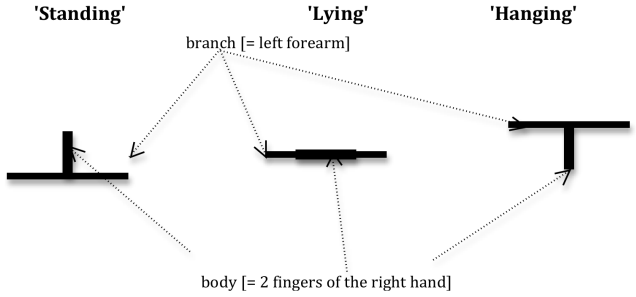
(41) Partial hypothesis
When evaluating the height of loci denotations for rule (38),
a. the position of c_a is assessed by considering the real or imagined position of the upper part of the body of c_a in c_w;
b. if s(i) is a person, the position of s(i) corresponds to the position of the upper part of the body of s(i) in c_w.

That something along these lines is necessary is suggested by the paradigm in (42), where we test patterns of preference among five different heights in sentences involving different body positions, with classifiers for people in standing, lying or hanging position. Target heights are numbered from 1 for the highest position, to 5 for the lowest one.[16] The classifier used denotes people in standing position (two fingers pointing downwards), in lying position (two horizontal fingers) or in hanging position (two fingers pointing upwards, but with flexed upper phalanges). We tried to ensure that the height of the (middle portion of the) human classifiers stayed approximately constant across all examples, which involved changing the position of the sign for *BRANCH* to make it higher in the

[16] We make no claim that the five levels are distinctive; the stimuli were created by asking the signer to distinguish among five levels. What matters for our purposes is the judgments obtained on the video; it can definitely not be inferred a difference among five levels could be obtained in naturalistic data.

'hanging' than in the 'standing' position, as is depicted in (42) (more sophisticated methods would be needed to guarantee that this is done rigorously; we leave this for future research).

(42) Rough position of the index and middle finger of the dominant hand and of the non-dominant hand in examples (43)



(43) *Context:* People have conversations in the weirdest of positions.
TREE BRANCH VERY TALL LINGUIST PERSON CL-_____$_a$ SAME VERY TALL PHILOSOPHER PERSON CL-_____$_b$. IX$^{-a1/2/3/4/5}$ UNDERSTAND IX$^{-b1/2/3/4/5}$.
'[A very tall linguis$_{t]a}$ was (a) standing on (b) lying on (c) hanging from a branch and [a very tall philosophe$_{r]b}$ was (a) standing on (b) lying on (c) hanging from a branch. He$_a$ understood him$_b$.'
Levels (1 = top; 5 = bottom)

a. CL-_____ = CL-stand
translation = 'standing on' (10, 106; 109; 137; 11, 16)
1. 5.33
2. <u>6.33</u>
3. 6.67
4. 5
5. 3

b. CL-_____ = CL-lie
translation = 'lying on' (10, 104; 107; 135; 11, 17)
1. 3.67
2. 5
3. 6.67
4. <u>5.67</u>
5. 3.33

c. CL-_____ = CL-hang
translation = 'hanging from' (10, 105; 108; 136; 11, 18)
1. 3
2. 3.33
3. <u>5.67</u>
4. 7
5. 4

In this paradigm, the sentence is kept constant, except for two parameters: the classifiers in positions a and b may correspond to a person in standing, lying or hanging position, as represented in (42); and the pronouns *IX-a* and *IX-b* index 5 different levels in each case (roughly, the same five levels across conditions; and in each case the two pronouns index the same level). As can be seen, there are subtle differences across conditions in the height that is preferably targeted: the preferred height (in bold) is slightly lower in the 'hanging' (= c4) than in the 'lying' and 'standing' conditions (= b3, a3); and the second preferred height (underlined) is lower in the 'lying' (= b4) than in the 'standing' (a2) condition. At the same time, extreme values are dispreferred, and the differences we do obtain are relatively small.

There are two conceivable reasons why extreme values are dispreferred. First, it could be that they were just 'too extreme' and hence phonologically or morphologically awkward. Alternatively, it these positions might be *too high* to represent the intended meanings, possibly because even in the

'standing' condition in (42) the position which is targeted (according to (41)a) represents the upper part of the body, which might not be 'high' enough to correspond to a very high locus. Importantly, on this latter hypothesis, the analysis in (38) is insufficient, since it is strictly based on *orderings* relative to a neutral locus and has no notion of preservation of *distances*. But it would be easy to introduce the latter notion in the analysis, for instance by making explicit reference to heights (rather than just to the 'higher than' relations), as in (44):

(44) *Height specifications* (3rd try)
Let c be a context of speech, s an assignment function and w a world (with c_a = the author of c; c_w = the 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 is a measure (given by the context c) of heights of objects in c_w, and $\alpha_c > 0$ is a parameter given by the context c,

$[[\text{IX-i}]]^{c,s,w}$ = # iff s(i) = # or $\mathbf{|i - n| \neq 0}$ **and** $\mathbf{h_c(s(i)) - h_c(s(n)) \neq \alpha_c(h(i) - h(n))}$.
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 s(i) and s(n) be proportional to the height difference between the loci i and n, with a multiplicative parameter $\alpha_c > 0$. This imposes that orderings be preserved, but introduces the more stringent constraint that distances be preserved *modulo* the parameter α. Many variations could of course be considered, and at this point we do not attempt to adjudicate among them; but the greater precision of (44) will turn out to be useful in a related rule in Section 4.

3.4.3 Combining iconicity and reflexivity in ASL

The leading idea we develop is that loci are *both* variables and simplified pictures of what they represent. If so, we would expect that grammatical properties of variables in language can co-occur with iconic effects. This is indeed the case: in (45), we replicate the height preferences we saw in the previous section, with different patterns of acceptability for non-neutral heights. But these patterns are now observed with reflexive pronouns because the sentences involve a 'local binding' configurations; when a non-reflexive pronoun is used instead, sharp unacceptability ensues due to a violation of Condition B of the Binding Theory.[17]

(45) Context: People seek self-knowledge in the weirdest of situations.
YESTERDAY VERY TALL PHILOSOPHER PERSON $\_\_\_\_\__a$ OUTSIDE. SUDDENLY IX-$a^{\text{high / normal / low}}$ UNDERSTAND IX-$a^{\text{high / normal / low}}$ / SELF-$a^{\text{high / normal / low}}$
'Yesterday a very tall philosopher was standing / sitting / lying outside. Suddenly he understood him / himself.'

a. $\_\_\_\_\__a$ = STAND (10, 110; 113; 138; 11, 19)

1. High subject - high object	a. 2 IX	b. 6 SELF
2. Intermediate subject - intermediate object	a. 3 IX	b. 7 SELF
3. Low subject - low object	a. 1.33 IX	b. 3.33 SELF

b. $\_\_\_\_\__a$ = SIT (10, 111; 114; 139; 11, 20)

1. High subject - high object	a. 1.33 IX	b. 4.33 SELF
2. Intermediate subject - intermediate object	a. 2.67 IX	b. 7 SELF
3. Low subject - low object	a. 1.67 IX	b. 4.67 SELF

c. $\_\_\_\_\__a$ = LIE (10, 112;115; 140; 11, 21)

1. High subject - high object	a. 1.33 IX	b. 2.67 SELF

[17] Note that these data are compatible with two types of theories. On a 'direct interpretation' theory, height properties of loci are interpreted on reflexive pronouns in the same way as on normal pronouns. On an alternative 'agreement theory', these properties are merely inherited on the reflexive pronoun, and are interpreted on the subject pronoun only. We leave a discussion of these alternatives for future research.

2. Intermediate subject - intermediate object	a. 2.67 IX	b. 7 SELF
3. Low subject - low object	a. 2 IX	b. 6.33 SELF

We conclude that the 'iconic' component of height denotations can be found to accompany their 'grammatical' use: *SELF* is clearly a grammatical element (it is not a simple pointing sign that could somehow be treated a gesture), but it displays all the hallmarks of the iconic effects we studied in this section. For this reason, our approach is one in which iconic properties are fully integrated to the semantics in general, and to the interpretive rules for variables in particular. An alternative, developed by Cogill-Koez 2000 and Macken et al. 2003, would be to postulate that sign language has access to two separate systems, one grammatical, and one iconic. But the challenge for such a view is to explain how *SELF* can display properties of *both* systems.

3.5 An extension: deictic pronouns

When individuals are present in the discourse situation, one normally refers to them by (roughly) pointing towards them. In other words, in such cases the locus must roughly correspond to the position of the person it denotes. The general format we introduced in (39) can be used to capture this fact, as shown in (46):

(46) Deictic elements
Let c be a context of speech, s an assignment function and w a world.
If *IX-i* is a pronoun indexing locus i, and if s(i) is present in the discourse situation around c,
$[[\text{IX-i}]]^{c, s, w} = \#$ iff s(i) = # or **s(i) is present in the extra-linguistic situation and 1, i and s(i) are not roughly aligned**.
If $[[\text{IX-i}]]^{c, s, w} \neq \#$, $[[\text{IX-i}]]^{c, s, w} = s(i)$.

In words: if s(i) is present in the discourse situation, then if the signer points towards locus i he should be pointing in the direction of s(i) as well.[18]

This rule has an interesting consequence in a rather peculiar case. Sometimes, the locus assigned to an individual 'moves' in signing space; specifically, when an individual has been associated with a spatial location, one may (but need not) refer to him by pointing towards the locus *assigned to that location* (e.g. Emmorey 2002). This phenomenon, which we may call 'locative agreement', is illustrated in (47) (from Schlenker 2011a); in the examples of locative shift discussed here, the loci are as depicted in (48).

(47) JOHN $[\text{WORK IX-a FRENCH CITY}]_a$ SAME $[\text{WORK IX-c AMERICA CITY}]_c$. IX-a IX-1 HELP IX-a, IX-c IX-1 NOT HELP IX-c.
'John does business in a French city and he does business in an American city.
There [= in the French city] I help him. There [= in the American city] I don't help him.' (4, 66b; 4 67 & 10.05.06; 10.05.11; 7, 214, 7,234)

(48) Approximate areas associated with the loci
(from the signer's perspective)

The same phenomenon holds of the anaphoric component of directional verbs – with the potential advantage that in this case the locus must be unambiguously interpreted as denoting an individual (in other cases, *IX-a* on its own could have a meaning akin to *there*; we study the case of directional verbs for empirical convenience, without adapting to them the rule in (46)). In particular, the directional

[18] In standard accounts, the denotation of deictic pronouns is taken to be provided by an assignment function whose initial value is itself provided by the context. Things are no different here: in a fully explicit definition of truth, we would need to specify that the assignment function s properly reflects the referential intentions of the agent of the context c, as is specified in (i).
(i) Definition of truth
If *S* is a sentence uttered in a context of speech c and if s is an assignment function which represents the referential intentions of the agent of c for the free indices of *S*, then *S* is true if and only if $[[S]]^{c, s, c_a} = 1$, where c_a is the agent of c.

version of *HELP* indexes loci corresponding to the subject (beginning of the movement) and to the object (term of the movement) [by contrast, the plain verb version does not index any locus][19]. The baseline is in (49)a, where we see that locative agreement is possible with a third person argument. With an indexical (second person) argument, the result is degraded, as in (49)b. This is as expected, since the denotation of an indexical pronoun is present in the discourse situation and thus falls under rule (46).

(49) a. 5.88 JOHN IX-b WORK [IX-a FRENCH CITY]$_a$ SAME WORK [IX-c AMERICA CITY]$_c$.
IX-a IX-2 2-HELP-a. IX-c IX-2 NOT 2-HELP-c.
'John does business in a French city and he does business in an American city.
There [= in the French city] you help him. There [= in the American city] you don't help him.'

b. 2.5 IX-1 WORK [IX-a FRENCH CITY]$_a$ SAME WORK [IX-c AMERICA CITY]$_c$.
IX-a IX-2 2-HELP-a. IX-c IX-2 NOT 2-HELP-c.
'I do business in a French city and I do business in an American city. There [= in the French city] you help me. There [= in the American city] you don't help me.'
(8, 3; 8, 4; 8, 25; 8, 54; 10, 130)

Deictic third person pronouns and agreement markers are expected to fall under the same generalization; this might be correct, but the judgments are less sharp (and they would need to be checked in greater detail, with an explicit context in the video to ensure that the pronoun is indeed interpreted deictically).

(50) a. 6.5 JOHN IX-b WORK IN [IX-a FRENCH CITY $_a$ SAME [IX-c AMERICA CITY]$_c$. IX-a IX-1 1-HELP-a. IX-c IX-1 NOT 1-HELP-c.
'John works in a French city and in an American city. There [= in the French city] I help him. There [= in the American city] I don't help him.'

b. 4 IX-b WORK IN [IX-a FRENCH CITY]$_a$ SAME [WORK IX-c AMERICA CITY]$_c$. IX-a IX-1 1-HELP-a. IX-c IX-1 NOT 1-HELP-c.
Intended: 'He [pointing to someone next to the addressee] works in a French city and in an American city. There [= in the French city] I help him. There [= in the American city] I don't help him.'
(10, 133;134; 12.07.23e (cf. 8, 9; 10))

We leave for future research a more detailed investigation of this rule, but conclude that its general format falls under the iconic requirements we developed on entirely independent grounds to analyze height specifications of loci: the general format in (39) has thus more than one use.

3.6 Conclusion: one or two systems?

In our analysis of high and low loci, we have presented the iconic component as being intimately connected with the grammatical component, in sense that the semantic rules we posited for high loci were modeled after the semantics of gender features, but still made reference to a geometric projection between the space of loci and the space of their denotations. There are two ways in which this integration of the iconic component to the grammar might prove incorrect. First, it could be that the geometric component can in the end be dispensed with, as is the case in the conservative statement in (40), where the fact that high loci are realized high happens to be an idiosyncratic property of their phonology; if so, these might be grammatical elements with a gestural origin but a purely grammatical behavior. Second, it could be that we see in these cases two systems interacting without being integrated, as suggested for other cases in Cogill-Koez 2000 and Macken et al. 2003: a grammatical system on the one hand, and a gestural system on the other. But the difficulty is to explain *how* their interaction is to be derived. We already noted that such an approach would have to posit that *SELF* belongs to both systems. In addition, it is particularly striking that the contrast in (37) (which was

[19] A version of the plain verb is found here: http://www.signingsavvy.com/search/help. A version of the directional verb is found here: http://www.signingsavvy.com/search/help+me.

robust for our ASL consultant) seemed to match rather closely subtle contrasts obtained with gender features in English. It could be that the similarity is in the end an accident, but at this point it is suggestive of a possible connection between the semantic rules used for high loci and for gender features. Of course much more empirical research is needed to explore this potential generalization with more rigorous methods.

4 Directional verbs and locus-internal iconicity

4.1 The debate about directional verbs

Directional verbs are realized as signs that target the locus of at least one of their arguments. An example is given in (51): it involves the verb *1-ASK-2* ('I ask you'), realized as a movement connecting the speaker locus with the addressee locus.

(51) 1-ASK-2
'I ask you'
(material courtesy of Bill Vicars and www.lifeprint.com)

Despite numerous disagreements, Liddell 2003 and Lillo-Martin and Meier 2011 both note that there are clear iconic effects with directional verbs, some of which *target different parts of a locus depending on their meaning*. Thus Liddell 2003 writes that "*ASK-QUESTION*$^{-y}$ is directed toward the chin/neck area", while "*COMMUNICATE-TELEPATHICALLY-1*$^{[RECIP]\_y}$ (...) is directed toward the forehead". In fact, a similar observation was made early on by Kegl (2004, written in 1977), who noted:

"It has been argued up until now that pronominal reference consists of pointing to particular points in space. We have begun to collect evidence in favor of an alternative analysis which maintains that agreement markers and independent pronouns are not simply points in space but are actual non-visible entities positioned at particular points in space. These entities, although not visible (physically realized), are nonetheless treated as physically real objects."

The challenge is to incorporate these insights into a formal theory that also does justice to the anaphoric nature of directional verbs (see also Hou and Meier 2012 for a discussion of the height specifications of first person directional verbs).

Lillo-Martin 1991 and Lillo-Martin and Meier 2011 posit that directional verbs have overt or null arguments whose features *and referential index* they copy. This gives rise to two cases, depending on whether the arguments are overt or null: in (52)a, the directional verb *INFORM* copies the indexes of the subject *MARY*, associated with locus *a;* and of the object *SUE*, associated with locus *b*. In (52)b, the directional verb *SEND* copies the indexes of two null pronouns (in this case, we have kept the transcription conventions of the original examples).

(52) a. Overt arguments
a-MARY a-INFORM-b b-SUE a-IX PASS TEST (Lillo-Martin and Meier 2011)
'Mary$_1$ informs Sue$_2$ that she$_1$ passed the test.'
b. Null arguments
A. Did John send Mary the letter?
B. YES, a-SEND-b (Lillo-Martin and Meier 2001)
analyzed as: Ø-a a-SEND-b Ø-b
where *Ø-a* and *Ø-b* are null pronouns licensed by agreement.

One particularly striking argument for this analysis goes back to Lillo-Martin 1991, who showed that Strong Crossover effects (i) hold in ASL, (ii) are obviated by resumptive pronouns, and (iii) are *equally* obviated by directional verbs with no overt arguments (but displaying agreement) [part of this generalization is further supported in Schlenker and Mathur 2012]. The latter point strongly suggests that directional verbs can always license null pronouns, which in these cases behave like resumptive pronouns. This argues for a grammatical theory, one in which directional verbs have an anaphoric component. Liddell 2003, by contrast, forcefully argues that iconic effects found with directional verbs remain unexplained unless one gives a central place to their iconic dimension:

"Each individual verb has specific gestural characteristics associated with it. (...) For those that do point, if they are directed at a person, they are directed at specific parts of the person (e.g. forehead, nose, chin, sternum). These are not general characteristics of gestural 'accompaniments' to signing. These are specific, semantically relevant, properties of individual verbs."

We will now suggest that the two sides of the debate can be reconciled, but only if a semantics is introduced in which (i) loci are structured areas of space, as Liddell argued, and (ii) semantic rules can include iconic requirement.

4.2 Iconic effects with directional verbs

4.2.1 Lexical effects

On an empirical level, we show (a) that Liddell's claims also hold of donkey and bound pronouns, and (b) that in some cases the particular part of a locus which is targeted by agreement *depends on the position (upright or hanging) of the person referred to,* which argues for the kind of rich iconic component we posited in (44).

The basic effect discussed by Liddell is exemplified in (53), where four different heights are for the loci 1 and 2 (the same for both loci) are contrasted:

(53) YESTERDAY THE-TWO-1,2 MEET. THE-TWO-1,2
1. 1,2-ASK-QUESTIONS
2. 1,2-COMMUNICATE-BY-TELEPATHY
'Yesterday the two of us met. We 1. asked each other questions 2. communicated by telepathy with each other.' (8, 322; 323; 12.07.23e)

Condition:	1. 1,2-ASK-QUESTIONS	2. 1,2-COMMUNICATE-BY-TELEPATHY
a. high	4	7
b. medium high	7	4.5
c. medium low	6.5	2
d. low	2.5	1

Unsurprisingly, Liddell's claim is verified: *COMMUNICATE-BY-TELEPATHY* targets a higher position than *ASK-QUESTIONS*. In (54), we attempted to test a version of the same example in which pronouns are dependent on existential quantifiers, and obtained similar results – which suggests that the height preferences of directional verbs do not just show up with indexical/deictic arguments.

(54) YESTERDAY [LINGUIST PERSON]$_a$ MEET [PHILOSOPHY PERSON]$_b$. THE-TWO-a,b
1. a,b-ASK-QUESTIONS
2. a,b-COMMUNICATE-BY-TELEPATHY
'Yesterday a linguist met a philosopher. They 1. asked each other questions / 2. communicated by telepathy.' (8, 320; 321; 12.07.23e)

	1. a,b-ASK-QUESTIONS	2. a,b-COMMUNICATE-BY-TELEPATHY
a. high	5	7
b. medium high	6.5	4.5
c. medium low	7	2
d. low	3	1

Still, although the contrasts are clear, the paradigm is flawed: in (54), the signer prefers a two-sign expression, *THINK COMMUNICATE-BY-TELEPATHY*, rather than the single sign used in (54).

Probably to circumvent this problem, the signer applied a small Role Shift (= body shift realizing a kind of context shift[20]) to (54)2., which for this reason does not form a minimal pair with (54)1.[21]

A more minimal pair is provided in (55), which contrasts the levels targeted by *LOOK* (medium high level) vs. *EXCHANGE* (intermediate level).[22] The signer tried to ensure that the five levels tested remained constant across examples so as to allow for a comparison.

(55) *Context:* People have interactions in the weirdest situations.
YESTERDAY TREE BRANCH LINGUIST PERSON CL-stand$_a$ PHILOSOPHER PERSON CL-stand$_b$.
1. a,b-LOOK-rep.
2. a,b-EXCHANGE-rep QUESTION ANSWER.
'Yesterday a linguist was standing on a tree and a philosopher was standing on a tree.
1. They looked at each other continuously.' (10, 116; 120; 141; 11, 1)
2. They exchanged questions and answers.' (10, 117; 121; 142; 11, 2)
Levels: a = highest, e = lowest

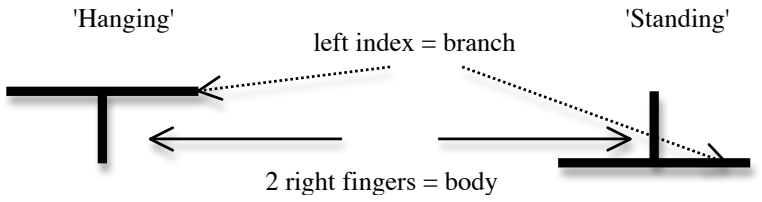
1. a,b-LOOK-rep.	2. a,b-EXCHANGE-rep QUESTION ANSWER.
a. 6.33	a. 5.67
b. 7	b. 6
c. 6.33	c. 7
d. 4.33	d. 6.67
e. 2.33	e. 3.67

While there the two verbs displays different patterns of preferences, the contrast is more subtle than with *ASK* vs. *COMMUNICATE-BY-TELEPTHY*. For *LOOK,* level b is preferred and level d quite degraded, while for *EXCHANGE* level c is preferred and level d is quite possible. Establishing this contrast more rigorously would require more sophisticated methods in order to guarantee that the levels targeted are strictly comparable across videos; we discuss one further test in (60).

4.2.2 The role of orientation

In the examples we considered, directional verbs target positions that correspond to the upper part of the body, *assuming that the individuals denoted are in upright position*. An iconic analysis predicts that when the individuals are heads down – for instance hanging rather than standing or sitting – the height preferences should be reversed. This was tested in (57). The signer tried to ensure that the vertical space occupied by the ('hanging' or 'standing') person classifier was the same in the 'hanging' condition in (57) as it was in the 'standing' position in (55), as is illustrated in (56). In addition, the signer tried to ensure that the five levels targeted were the same in (57) as in (55).

(56)



[20] See for instance Quer 2005 for a discussion of Role Shift and context shift in sign language.
[21] Thanks to Oliver Pouliot for pointing this out.
[22] As an anonymous referee points, *LOOK* could also be treated as a spatial verb, in which case the object indexed would be a spatial rather than an individual locus. It would be desirable to replicate these data with a 'pure' directional verb that only indexes individual loci.

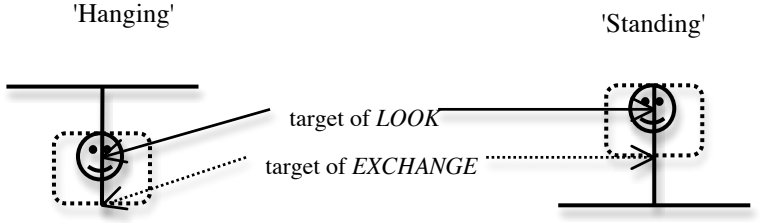
(57) *Context:* People have interactions in the weirdest situations
YESTERDAY TREE BRANCH LINGUIST PERSON CL-hang$_a$ PHILOSOPHER PERSON CL-hang$_b$.
1. a,b-LOOK-rep.
2. a,b-EXCHANGE-rep QUESTION ANSWER.
'Yesterday a linguist was hanging from a tree and a philosopher was hanging from a tree.
1. They looked at each other continuously.' (10, 118; 122; 143; 11, 3)
2. They exchanged questions and answers.' (10, 119; 123; 144; 11, 4)
Levels: a = highest, e = lowest

1. a,b-LOOK-rep.	2. a,b-EXCHANGE-rep QUESTION ANSWER.
a. 2.33	a. 2.67
b. 3.33	b. 3
c. 5.67	c. 5
d. 6.67	d. 7
e. 4.67	e. 6

The iconic analysis makes two predictions:
–First, keeping the verb constant, the preferred heights should be lower in the 'hanging' condition than in the 'standing' condition, despite the fact that the absolute position of the classifier remains roughly constant (this prediction is made because the position which is targeted corresponds to the upper part of the body, hence if the body is upside down the target should be lower).
–Second, comparing heights across verbs, *LOOK* should target a lower position than *EXCHANGE* in the 'hanging' condition and a higher position than it in the 'standing' position – a prediction we term 'reversal'.

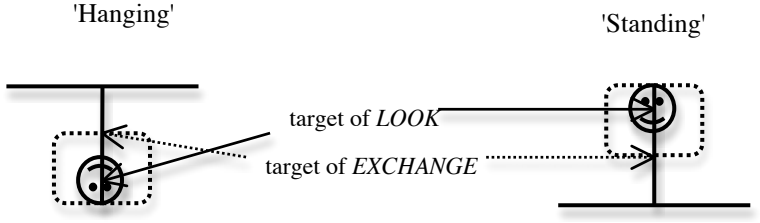
The first prediction is confirmed but the second is not, as shown by the ratings in (57). In both cases, the preferred target height is lower than in (55), but we do not find the expected reversal of preferences for *LOOK* vs. *EXCHANGE*. Importantly, we find a blurred effect: the difference between the two verbs seems to be erased in the 'hanging' condition. Two analyses present themselves.
(i) Possibility I: reversal of body position affects the *general area* targeted by directional verbs and possibly pronouns (as was already seen in (42)), but not the relative heights within that area. This is illustrated in (58).

(58)



(ii) Possibility II: the methods used in (57) are insufficiently fine-grained to elicit clear contrasts in the hanging position; with more fine-grained methods, we could obtain the expected reversal, depicted in (59):

(59)



Needless to say, Possibility I is not consistent with a simple statement of an iconic constraint; it would require a rather complex analysis, as some aspects of body orientation need to be taken into account (since the dashed area is lower in the 'hanging' condition in (58) than in the 'standing' condition), while others must be disregarded (since in both conditions the target of *LOOK* is higher than the target of *EXCHANGE*). Possibility II is in this respect simpler.

We believe that, in some cases at least, Possibility II is correct (we leave it entirely open whether this depends on the language, on the verb, or on the signer). In (60), we obtained clearer contrasts by (i) including in one and the same sentence two directional verbs, *SAY-NO-TO* (high target) and *EXCHANGE* (intermediate target), and by (ii) asking the signer to contrast three conditions, one in which: (a) *SAY-NO-TO* targets a position higher than *EXCHANGE (*written below as *SAY-NO-TO > EXCHANGE*)*;* (b) *SAY-NO-TO* targets the same height as *EXCHANGE (SAY-NO-TO = EXCHANGE)*; and (c) *SAY-NO-TO* targets a position lower than *EXCHANGE (SAY-NO-TO < EXCHANGE*). In this way, the task was intrinsically comparative, which made it easier to determine whether one verb targets a higher position than the other.

(60) *Context:* People have interactions in the weirdest situations
YESTERDAY THERE TREE BRANCH LINGUIST PERSON $\_\_\_\__a$ PHILOSOPHER PERSON $\_\_\_\__b$. a,b-EXCHANGE-rep QUESTIONS ANSWERS BUT CONTINUALLY a,b-SAY-NO-TO-rep.
'Yesterday a linguist was _____ a branch and a philosopher was _____ a branch. They exchanged questions and answers but continually said no to each other.'

1. _____ = CL-stand
translation = 'was standing on' (11, 99; 101; e12.07.24)

a. 5.5 SAY-NO-TO > EXCHANGE
b. 7 SAY-NO-TO = EXCHANGE
c. 2.5 SAY-NO-TO < EXCHANGE

2. _____ = CL-hang
translation = 'was hanging from' (11, 100; 102; e12.07.24)

a. 3.5 SAY-NO-TO > EXCHANGE
b. 7 SAY-NO-TO = EXCHANGE
c. 6.5.5 SAY-NO-TO < EXCHANGE

As is predicted by Possibility II but not by Possibility I, reversal occurs in this case: *SAY-NO-TO* can target a lower position than *EXCHANGE* in the 'hanging' but not in the 'standing' condition, as shown in (60)2c vs. (60)1c. One fact remains unaccounted for, however: in both conditions, it is perfect – and in fact slightly preferable – for both verbs to target the same height. We hypothesize that this is because the scene is represented as sufficiently distant that body-internal differences in height are small relative to the scene depicted. We do not seek to account for this further subtlety in the present piece. (We also remain agnostic as to the behavior of *LOOK*, which might well be different. Similarly, *COMMUNICATE-BY-TELEPATHY* doesn't seem to be easily affected by changes of body orientation, for reasons we do not understand.)

Importantly, these data does not tell us how fine-grained the typology of directional verbs should be, and in particular how many heights can in principle be distinguished within a locus; more work is needed before this issue can be settled (see Liddell 2003 and Hou and Meier 2012, among others).

4.3 Extension to LSF

In this section, we extend to LSF our main findings from ASL (see Appendix I for a brief discussion of LIS data).

❑ *Height differences with directional verbs*

In (61), we contrast the directional 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 (in this video, low loci were just unacceptable). Judgments for *EXCHANGE-THOUGHTS* were given with respect to the intended meaning; another meaning could be obtained with intermediate loci: 'exchange emails' or 'exchange text messages'.

(61) YESTERDAY LINGUIST$_b$ PHILOSOPHER$_a$ b,a-MEET.[23]

1. b,a-EXCHANGE-THOUGHTS 2. b,a-COMMUNICATE-BY-TELEPATHY
'Yesterday, a linguist and a philosopher met. They 1. exchanged thoughts 2. communicated by telepathy.' (19, 68 Inf H; 19, 69 Inf H; 19, 86 Inf I; 19, 96 Inf I; 19, 97 Inf H; 19, 146 Inf J[24]; 19, 156 Inf J; 20, 158 Inf H)

a. High locus
1. 2 [2.17] b^{high},a^{high}-EXCHANGE
2. 6.4 [6.5] b^{high},a^{high}-COMMUNICATE-BY-TELEPATHY

b. Intermediate locus
1. 6.4 [6.50] b^{medium},a^{medium}-EXCHANGE
2. 3 [3] b^{medium},a^{medium}-COMMUNICATE-BY-TELEPATHY

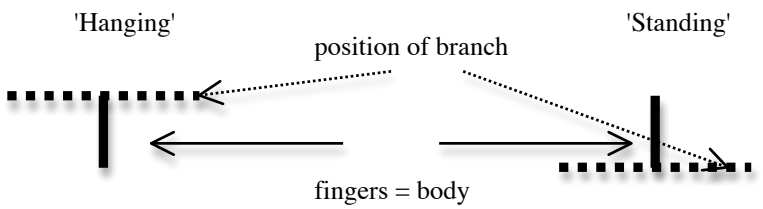
c. Low locus
1. 1.2 [1.17] b^{low},a^{low}-EXCHANGE
2. 1 [1] b^{low},a^{low}-COMMUNICATE-BY-TELEPATHY

We conclude that LSF, like ASL, gives rise to height differences with respect to directional verbs – in particular with respect to the LSF counterparts of the ASL verbs discussed in Liddell 2003 and Kegl 2004.

❑ *Replicating the orientation argument*

We replicated the initial argument from body orientation in LSF. In (63), 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. As in our ASL examples in (56), 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 (62).

(62)



[23] In this case, the initial sentence was *not* repeated with each condition appearing on this video, unlike what we did with other examples.

[24] In this trial, Inf J had slightly misunderstood the instructions and assessed both the video on its own and its adequacy to the gloss/translation provided in the judgment sheet (the instruction was to only assess the video on its own; glosses/translations were provided as a means to avoid any confusions due to misnumbering).

(63) 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 wanted me to ask him questions.' (Inf J 20, 9; Inf J 20, 10; Inf H 20, 167)
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, three target heights were tested for the directional verb *ASK*: high, intermediate and low. Judgments on a 7-point scale were obtained from the original signer (Inf J) and from another native LSF signer who rated the very same video (Inf H). The judgments are fairly similar for both consultants:
–both disliked the low locus, though more so in the 'standing' than in the 'hanging' condition.
–both found the high locus relatively acceptable in the 'standing' condition, and the intermediate locus acceptable in the 'hanging' condition.[25]

We also attempted to sharpen the data by replacing 'several of my friends' with 'several giants' in (63). The preferences for high vs. low loci seen there were amplified: in (64), there is a sharp preference for high locus in the 'standing' condition, for the low locus in the 'hanging' condition.

(64) TREE BRANCH SEVERAL GIANT [GIANT SEVERAL][26] 1. HANG-rep / 2. STAND-rep
IX-a WANT IX-1 1-ASK-a$^{high\ /\ medium\ /\ low}$-rep.
'Several giants were 1. hanging from 2. standing on a tree branch. One of them told me he wanted me to ask him questions.' (Inf J 20, 11; Inf J 20, 12; Inf H 20, 168)
a. High locus: 1-ASK-a^{high}
1. 1
2. 6.5
b. Intermediate locus: 1-ASK-a^{medium}
1. 3
2. 3.5
c. Low locus: 1-ASK-a$^{high\ /\ medium\ /\ low}$
1. 6.5
2. 1

A more direct argument for reversal is afforded by the sentence in (65): two directional verbs targeting different heights, *TELEPATHY* (high target) and *EXCHANGE* (intermediate target) 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 (65)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). The video was signed and rated by informant H. Informant J didn't know the particular word used by informant H for 'telepathy', but he obtained similar judgments in a slightly more complex sentence signed by himself (see Appendix II).

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[25] In a similar task with an earlier and possibly less clear video, signed by Inf H, a third native LSF informant, Inf I (hearing child of deaf parents) failed to display the 'reversal' effect found across the 'standing' vs. 'hanging' conditions. We do not know whether this is because he did not understand the situation in the intended way, or because his dialect is guided by different rules. More work is needed on this issue.
[26] The signer used *SEVERAL GIANT* or *GIANT SEVERAL* depending on the condition.

(65) 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.CL- ____ = CL-hang (23, 15; 17; 23, 28)
a. 2 TELEPATHY > EXCHANGE
b. 3.5 TELEPATHY = EXCHANGE
c. 6 TELEPATHY < EXCHANGE

2. CL- ____ = CL-stand (23, 14; 16; 23, 27)
a. 6 TELEPATHY > EXCHANGE
b. 3.5 TELEPATHY = EXCHANGE
c. 2 TELEPATHY < EXCHANGE

4.4 An analysis with structured loci

Our analysis is based on two ideas: (i) loci are not (always) points, but they are (or can be) structured areas, as Liddell 2003 and Kegl 2004 argued; (ii) the lexical semantics of directional verbs has an iconic component, which requires that the target of the movement correspond to a particular part of the object denoted by the locus. Here too, we implement this requirement in terms of a presuppositional semantics (it should be emphasized that this is primarily for convenience: here we did not specifically test the presuppositional nature of height requirements, unlike what we did in Section 3).

We start by revising our earlier assumptions and propose that assignment functions assign values to areas of space rather than to points:

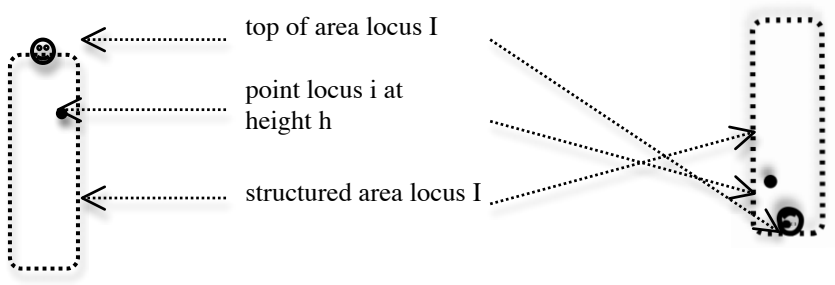
(66) Assignment functions assign values to **structured areas** of space ('area loci', with an instrinsic 'head' and 'foot' position) rather than to **points** of space ('point loci'). Lower-case letters (e.g. *a*) designate point loci; capital letters (e.g. *A*) designate area loci; assignment functions assign values to variables and capital letters. (We extend this notational convention to *1*, *2*, which are traditionally used to designate the speaker and addressee; we take these to stand for point loci, the corresponding area loci being *I* and *II*.)

Our analysis gives directional verbs a presuppositional semantics. To illustrate it on a more familiar case, we start with a toy example: we assume that person marking on verbs has a presuppositional semantics (a more standard view is that person marking is interpreted on pronouns but not on verbs, and that person marking on the latter results from morphosyntactic agreement; but since our goals are purely didactic at this point, we disregard this fact). On this view, *am-working* gives rise to a presupposition failure unless its argument denotes the speaker, as is defined in (67):

(67) For any objects x and y of type e, for any context c and assignment function s,
$[\![\text{am\_working}]\!]^{c,s,w}(x) = \#$ iff $x = \#$ or $x \neq c_a$. If $\neq \#$, $[\![\text{am\_working}]\!]^{c,s,w}(x) = 1$ iff x is working.

We posit a similar presuppositional semantics for directional verbs, but with an explicit iconic requirement (in the cases we study, they will hold both of the subject and of the object argument). It 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 (68).

(68) 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)



We can now posit the lexical semantics in (69), where the iconic requirements appear in bold; they force the point locus targeted by the verb to be at the same relative height within its area locus as the chin of the denotation relative to the body of the denotation. For clarity, it is initially useful to abbreviate the condition as in (69)a; conditions (i) and (ii) should be read more precisely as in (69)b.

(69) For any objects x and y of type e, for any context c, assignment function s, and world w, if h is a measure of the heights of loci in signing space, $h_{c,w}$ is a measure given by the context c of height denotations in the world w,

a. Abbreviated definition

$[\![\text{i-ASK-QUESTIONS-j}]\!]^{c,s,w}(y)(x) = \#$ iff x = # or y = # or s(J) ≠ y or s(I) ≠ x or

(i) the relative height of the point locus i in the area locus I is not roughly equal to the relative height of the chin of s(I) in the body of s(I), or

(ii) the relative height of the point locus j in the area locus J is not roughly equal to the relative height of the chin of s(J) in the body of s(J).

If $[\![\text{i-ASK-QUESTIONS-j}]\!]^{c,s,w}(y)(x) \neq \#$, $[\![\text{i-ASK-QUESTIONS-j}]\!]^{c,s,w}(y)(x) = 1$ iff x ask questions to y in w.

b. Abbreviations

(i) = [h(i) - h(foot(I)]/|h(head(I) - h(foot(I)| is not roughly equal to $[h_{c,w}(\text{chin}(s(I)) - h_{c,w}(\text{bottom}(s(I)))]/|h_{c,w}(\text{top}(s(I)) - h_{c,w}(\text{bottom}(s(I)))|$

(ii) = [h(j) - h(foot(j)]/[h(head(j) - h(foot(j)] is not roughly equal to $[h_{c,w}(\text{chin}(s(J)) - h_{c,w}(\text{bottom}(s(J)))]/|h_{c,w}(\text{top}(s(J)) - h_{c,w}(\text{bottom}(s(J)))|$

where *bottom(s(I))* and *top(s(I))* refer respectively to the lower and upper parts of individual s(I), while *foot(I)* and *head(I)* refer to the foot and to the head of the area locus I.

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 at the 'same height' relative to the foot of *I* as the chin of s(I) is relative to the lower part of s(I) (exactly what counts as the 'lower part' of s(I) is left open here); and similarly for *j*, *J*. To account for scaling, 'same height' is relativized to the size of the locus and of the object it denotes; this is why in the full version of condition (i), which appears in (69)b, we don't have a requirement that

$h(i)-h(\text{foot}(I) = h_{c,w}(\text{chin}(s(I))-h_{c,w}(\text{bottom}(s(I)),$

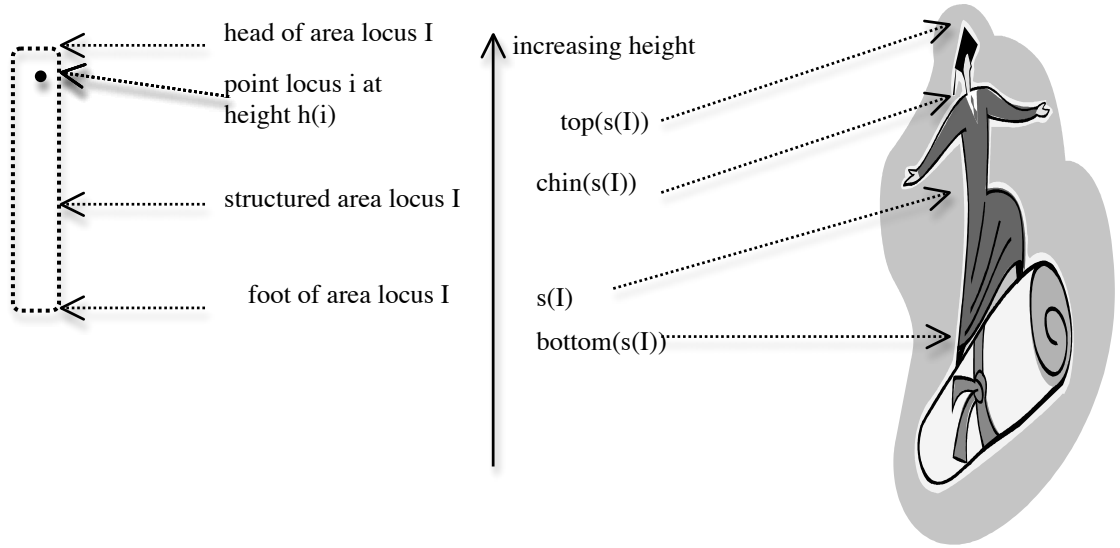
but rather that

$[h(i)-h(\text{foot}(I)]/|h(\text{head}(I)-h(\text{foot}(I)| = [h_{c,w}(\text{chin}(s(I))-h_{c,w}(\text{bottom}(s(I)))]/ |h_{c,w}(\text{top}(s(I))-h_{c,w}(\text{bottom}(s(I)))|.$

This is because $|h(\text{head}(I) - h(\text{foot}(I)|$ and $|h_{c,w}(\text{top}(s(I)) - h_{c,w}(\text{bottom}(s(I)))|$ are measures of the vertical size of the locus I and of its denotation s(I) respectively, hence their use in defining the proper notion of 'same relative height'.

Condition (i) (69) is illustrated in (70), which represents a 'standing' situation in which [h(i) - h(foot(I)]/|h(head(I) - h(foot(I)| is positive.

(70)



In a 'hanging' situation, with the area locus I upside down, [h(i) - h(foot(I)]/|h(head(I) - h(foot(I)| is negative because the point locus i is lower than the foot of the area locus I, and as a result the denotation s(I) must be in upside down position as well (in order to ensure that [$h_{c,w}$(chin(s(I)) - $h_{c,w}$(feet(s(I)))]/ |$h_{c,w}$(bottom(s(I)) - $h_{c,w}$(top(s(I)))| is negative too).

The lexical entry in (69) 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, (69) only makes sense if the areas of space assigned as the value to capital letters are *oriented*, with a head and a foot, as specified in (66); otherwise we couldn't speak *of the relative height of i within I*. Finally, as was the case in our analysis of height specifications of pronouns in (39), this lexical entry is of the general form in (71), where the part in bold corresponds to an iconic relation that must be preserved by the interpretation (on pain of presupposition failure).

(71) ... $[[\text{i-ASK-QUESTIONS-j}]]^{c,s,w}(y)(x) = \#$ iff x = # or y = # or s(J) ≠ y or s(I) ≠ x or **i, I do not stand in iconic relation R to s(I) in c_w or j, J do not stand in iconic relation R to s(J) in c_w.**
If $[[\text{i-ASK-QUESTIONS-j}]]^{c,s,w}(y)(x) = \neq \#$, $[[\text{i-ASK-QUESTIONS-j}]]^{c,s,w}(y)(x) = 1$ iff x ask questions to y in w.

For *COMMUNICATE-BY-TELEPATHY*, the rule is the same, except that (i) there is no temporal asymmetry between i, j (both loci appear at the origin of the movement – one for each hand); and (ii) the part of the structured locus which is targeted is the forehead rather than the chin.[27]

(72) For any objects x and y of type e, for any context c, assignment function s, and world w
$[[\text{i-j-COMMUNICATE-BY-TELEPATHY}]]^{c,s,w}(y)(x) = \#$ iff x = # or y = # or s(J) ≠ y or s(I) ≠ x or
(i) the relative height of the point locus i in the area locus I is not roughly equal to the relative height of the <u>forehead</u> of s(I) in the body of s(I), or
(ii) the relative height of the point locus j in the area locus J is not roughly equal to the relative height of the <u>forehead</u> of s(J) in the body of s(J).
If $[[\text{i-j-COMMUNICATE-BY-TELEPATHY}]]^{c,s,w}(y)(x) \neq \#$, $[[\text{i-j-COMMUNICATE-BY-TELEPATHY}]]^{c,s,w}(y)(x) = 1$ iff x communicates by telepathy with y in w.

To illustrate how the system works, consider the sentence *John asks me questions*, i.e. *JOHN i-ASK-QUESTIONS-1 $\emptyset_1$*, with *1* targeting the signer. At the first step of the semantic derivation, we just 'feed' the verb its arguments. *JOHN* denotes the individual John, and $\emptyset_1$ denotes whatever the assignment function specifies for area locus *I* denotes – in this case, the signer, hence s(I) = c_a (remember that *I* is the 'area locus' version of *1*, as specified in (66); and that c_a is the agent of the context c). Thus we obtain the step in (73):

(73) $[[\text{JOHN a-ASK-QUESTION-1 } \emptyset_1]]^{c,s,w} = [[\text{a-ASK-QUESTION-1}]]^{c,s,w}([[\emptyset_1]]^{c,s,w})([[\text{JOHN}]]^{c,s,w}) = [[\text{a-ASK-QUESTION-1}]]^{c,s,w}(s(I))(\text{John}) = [[\text{a-ASK-QUESTION-1}]]^{c,s,w}(c_a)(\text{John})$

We can now apply the lexical entry in (69), with y = c_a and x = John. It is immediate that x ≠ # and y ≠ #, and by assumption s(I) is the signer c_a. Taking these facts into account, we derive the desired presupposition, namely that *ASK-QUESTION* targets what corresponds to the 'chin' position of the signer – as well as of *A* (for legibility, we use the same kinds of informal abbreviations as in (69)a):

(74) $[[\text{JOHN a-ASK-QUESTIONS-1 } \emptyset_1]]^{c,s,w} = \#$ iff $[[\text{a-ASK-QUESTION-1}]]^{c,s,w}(c_a)(\text{John}) = \#$, iff
the relative height of 1 within I is not roughly equal to the relative height of the chin of c_a within the body of c_a in c_w, or the relative height of a within A is not roughly equal to the relative height of John's chin within John's body in c_w.

[27] As noted earlier, the iconic requirements on *COMMUNICATE-BY-TELEPATHY* might well be more complex than the present theory predicts: the expected reversal of the position targeted by the verb when the orientation of the area locus is reversed (as in (70)) does not seem to be realized.

It is worth noting that if, as is plausible, the area locus I is just the signer, we derive the result that the point locus 1 should target the signer's nose. When this presupposition is satisfied, we obtain the desired truth conditions:

(75) If $[[\text{JOHN a-ASK-QUESTIONS-1 } \emptyset_1]]^{c,s,w} \neq \#$, $[[\text{JOHN a-ASK-QUESTION-1 } \emptyset_1]]^{c,s,w} = 1$ iff [[a-ASK-QUESTION-1]]$^{c,s,w}(c_a)$(John) = 1, iff John asks questions to c_a in w.

In sum, we have offered a semantic analysis that combines the insights of the 'formalist' and of the 'iconic' camps: directional verbs are anaphoric expressions (they license null pronouns); but they also have a clear iconic component. The two observations are made compatible by the fact that our semantics allows variables to have an iconic dimension, analyzed here in presuppositional terms.

One question left entirely open by the present approach is the *degree of fine-grainedness* of the iconic component of our rules. There is some vagueness involved, as is highlighted by our use of the adverb *roughly* in our statement of the iconic conditions in (69)a-b (e.g. 'the relative height of the point locus j in the area locus J is not *roughly* equal to the relative height of the chin of s(J) in the body of s(J)'). In particular, we take no stand on how many distinct levels can be targeted by different directional verbs within a given structured locus; we leave this point for future research (see Hou and Meier 2012).[28]

5 Concluding remarks

In three domains – plural loci, high and low loci, and directional verbs – we made crucial use of a 'formal semantics with iconicity' in which some geometric properties of signs must be preserved by the interpretation function. All three cases concerned logical variables with an iconic component: logic and iconicity are thus integrated at the very core of sign language semantics. This leaves several questions open.

1. We investigated variables because of their centrality to many logical systems. But this is probably just the tip of the iceberg; the task is now to construct a formal semantics with iconicity for a variety of meaning phenomena in sign language. Our analysis might in this respect dovetail with important research conducted by Wilbur (e.g. 2003) on the 'visibility hypothesis', according to which key properties of event structure are made visible in the morphology of ASL verbs. Wilbur's approach is not explicitly iconic: for her, certain primitive elements of grammar just happen to be visible in sign language morphology; but it would be of great interest to ask how much of her analysis can be re-cast within the present framework.

2. Our analysis raises several architectural questions about the role of iconicity in grammar. (i) We claimed that it is present at the heart of the interpretive procedure, in particular in the meaning of variables. As mentioned, other researchers posit instead that two separate systems coexist within sign language. While we gave some arguments for a unified approach (e.g. the potential similarity between the semantics of high loci and that of gender features, or the fact that *SELF* simultaneously has a grammatical and an iconic function), the debate is still rather open (see for instance Cogill-Koez 2000, Emmorey and Harzig 2003 for different analyses of the iconic component of classifier predicates in sign language). (ii) Our interpretive rules make reference to the details of the *form* of loci – and this would seem to allow the semantics to have access to the details of the phonology, which is not a standard assumption; its repercussions need to be investigated. (iii) There is nothing in our approach to block the existence of iconic effects at the core of *spoken* language grammar as well – except of course for the iconic limitations of the sound stream; here too, the full repercussions of the present framework must be investigated further.

3. Within the phenomena we studied, our approach is not fully unified: while our three iconic analyses bear a family resemblance and can be made part of a single theory, they cannot be claimed to fall out of a single analysis. Some sub-theories might be further unified; for instance, one ought to ask whether there are commonalities between the structure of plural and individual loci. This would be

[28] We also leave open whether and how the present approach could be extended to spatial verbs, which may also display iconic properties.

particularly interesting in view of the common assumption that plurals simply denote plural *individuals*.

4. More generally, we defined the geometric properties to be preserved in a piecemeal fashion. A more general theory would be desirable, one in which *bona fide* geometric projections might conceivably play a role in the interpretation procedure. There are obvious links to be explored to recent work on the formal semantics of gestures (e.g. Giorgolo 2010) and of pictures (Greenberg 2012).

5. In order to handle the phenomena of interest, we had to increase the expressive power of our semantic framework. Some of the iconic rules we posited have the same format as grammatical rules posited for spoken language, for instance in the interpretation of gender features. But it is not yet clear which iconic effects are possible and which are not; *limits* must be added to the expressive power of a system with iconic rules.

6. It should also be asked whether iconic effects on variables can be replicated within spoken language. This is unlikely if we restrict attention to spoken words. But as D. Lillo-Martin and D. Brentari suggested (p.c.), it might prove enlightening to investigate the semantic effects of co-speech gestures that can accompany spoken language.

7. Finally, we left various empirical questions open in our discussions – notably with respect to directional verbs, where the possibility of 'reversal' appears to depend on the verb, language and/or signer. Even where we had clear data, these were from a small number of informants, and thus future work should explore our generalizations in greater depth, and in some cases (for instance those involving height preferences of directional verbs) with more sophisticated and rigorous methods.

Appendix I. Preliminary Extension to LIS

In this Appendix, we discuss a preliminary extension of our main results to Italian Sign Language (LIS). All videos were signed by informant S (= Santoro, one of the authors), a Deaf native signer of Deaf, signing parents; all judgments are his, except in the case of high and low loci, where judgments from informants D and C were also obtained.

- *Complement Set Readings in LIS*

In the main text, we saw that when a single (default) locus is used, ASL or LSF behave like English in allowing for maximal and restrictor set readings, but not for complement set readings. This generalization appears to hold in S's LIS as well: (76)a shows that when a single default locus is used, complement set anaphora is impossible.[29] When embedded loci are used instead, complement set anaphora becomes fully available, as shown in (77)a.

(76) STUDENT POSS-1 MOST CLASS IN.
'Most of my students are in class.' (23, 33; 38)
a. 1 IX-arc HOME STAY.
'They stayed home.' (= the LIS version is contradictory, as is the translation)
b. 6 IX-arc ASK-QUESTION-1 INTELLIGENT.
'They asked me good questions.'
c. 6 IX-arc CLASS SERIOUS.
'They are a serious class.'

(77) STUDENT POSS-1 IX-arc-ab MOST IX-a CLASS IN.
'Most of my students are in class.' (23, 35; 40)
a. 7 IX-b HOME STAY.
'They [= the ones who aren't in class] stayed home.'
b. 7 STUDENT POSS-1 IX-arc-ab MOST IX-a CLASS IN. IX-arc-a ASK-QUESTIONS INTELLIGENT.
'They [= the ones who are in class] ask intelligent questions.'
c. 6 STUDENT POSS-1 IX-arc-ab MOST_a IX-a CLASS IN. IX-arc-ab CLASS SERIOUS.
'They [= my students] are a serious class.'

- *High and low loci*

Facts pertaining to high and low loci are in part replicated with S and two further LIS informants, D and C. With an antecedent involving tall people, S and D accept a pronoun indexing a high locus in(78), while informant C only accepts an intermediate locus. In (79), which involves short people, informants S and C accept a pronoun indexing a low locus, while informant D only accepts a pronoun indexing a normal locus.

(78) PERSON TALL IX-a-$^{\text{high/normal/low}}$ THINK NOBODY LOVE IX-a$^{\text{high/normal/low}}$
'Every tall person thinks that nobody likes him.' (LIS 42)

Informant	S	D	C
a. High locus	7	7	1
b. Normal locus	5	3	7
c. Low locus	1	1	1

(79) PERSON DWARF EACH-a$^{\text{normal}}$ -rep a-THINK NOBODY LOVE IX-a$^{\text{high/normal/low}}$
'Every dwarf thinks that nobody likes him.' (LIS 45)

Informant	S	D	C
a. High locus	1	1	1
b. Normal locus	6	7	7
c. Low locus	6	1	6

[29] As is the case in English, the sentence improves when *MOST* is replaced with *FEW* (the rating becomes a 4), but as was mentioned in our discussion of (5)a, this might be because in such a situation a restrictor set reading 'with exceptions' is obtained.

As can be seen, the judgments are not fully consistent across signers. In addition, more work is needed to improve the stimuli. In (78), the antecedent *EACH-a*^{normal} was signed at the same (normal) height across all three conditions, and thus the availability of low pointing for some informants suggested that a semantic condition was at work (a morphological condition would just have required agreement in height between the pronoun and its antecedent). By contrast, in (78) the locus-establishing sign *IX-a* was signed at varying heights across the three conditions: high for a., normal for b., low for c. – and thus the acceptability of the pronoun indexing a high locus could be due to a morphological condition (= agreement in height with the antecedent), rather than to a *bona fide* semantic condition.

We obtained judgments from S on an improved version of (78), one in which the antecedent *EACH*$_a$ was signed at the same (normal) height across all three conditions. For S, a clear semantic effect is obtained: a high locus can be used while a low locus is unacceptable.

(80) PERSON TALL EACH$_a$^{normal}-rep a-THINK NOBODY LOVE IX-a$^{high/normal/low}$ (LIS 43)
'Every tall person thinks that nobody likes him.'
a. 7 High locus
b. 5 Intermediate locus
c. 1 Low locus

- *Directional verbs*

Our LIS data on directional verbs are preliminary: they track S's judgments in 'inversion' contexts, as in (81); as we did in (62), we tried to ensure that the space occupied by the person classifier remained approximately constant in the 'standing' and in the 'hanging' condition – which implied signing the word for 'branch' lower in the 'hanging' than in the 'standing' condition (for ease of comparison, all 6 examples were signed on the same video; due to the lack of temporal adverb, the discourse can be interpreted as present or past).

(81) TREE CL____, BRANCH CL____ LINGUISTICS$_a$ PHILOSOPHER$_b$ a,b-ARGUE^{normal} CL____HEAD$_{ab}$ a,b-BANG $^{high/normal/ low}$
'A linguist was/is hanging from / standing on a branch and a philosopher was/is hanging from / standing on a branch. They argue(d) and clash(ed) banging their heads.' (LIS 14-15 mod)

	1. 'Standing'	2. 'Hanging'
a. a,b-BANG > a,b-ARGUE	6	2
b. a,b-BANG = a,b- ARGUE	5	5
c. a,b-BANG < a,b- ARGUE	1	4

In the 'standing' condition, *BANG* (with the meaning of 'bang their heads') can target higher loci than *ARGUE;* if it targets lower loci instead, the result is quite deviant. In the 'hanging' situation, the two verbs preferably target the same level; when *BANG* targets higher loci than *ARGUE*, the result is very degraded; when *BANG* targets lower loci than *ARGUE,* the result is somewhat degraded.

Thus inverting the body position from 'standing' to 'hanging' has clear effects, in the sense that *BANG* can target higher loci than *ARGUE* in the 'standing' condition but definitely not in the 'hanging' condition. Still, we don't see all of the expected iconic effects, since in the 'hanging' condition it is not fully possible for *BANG* to target lower loci than *ARGUE*.

Appendix II. Complement on example (65)

As mentioned in Section 4.3, testing example (65) with Inf J proved difficult because he didn't know the word used by Inf J for 'telepathy'. In (82), we provide a slightly more complex example signed by Inf J himself, with *THINK TELEPATHY* involving a different sign from Inf H's example. Judgments are Inf J's and Inf H's. As can be seen, the reversal seen in (65) is replicated here: *TELEPATHY* targets a higher position than *EXCHANGE* in the 'standing' condition in 2., but the pattern is reversed in the 'hanging' condition in 1.

(82) YESTERDAY TREE BRANCH PHILOSOPHER CL-_____$_b$ LINGUIST CL-_____$_a$. THE-TWO-a,b IDEA EXCHANGE. THE-TWO-a,b THINK a,b-TELEPATHY NOT.
'Yesterday a philosopher and a linguist were standing on / hanging from a tree branch. They exchanged ideas but didn't communicate by telepathy.'

	1. 'Hanging' CL-hang (23, 30; 32)	2. 'Standing' CL-stand (23, 29; 31)
a. TELEPATHY > EXCHANGE:	1.5	6.5
b. TELEPATHY = EXCHANGE:	4.5	4
c. TELEPATHY < EXCHANGE:	6.5	1.5

Appendix III. Ratings

ASL ratings are usually based on repeated judgments by co-author Lamberton [JL]; in some cases two further informants [I4 and I5] provided ratings as well. LSF judgments are based on ratings by two informants, Inf H and Inf J.

Ratings are given on a 7-point a scale, preceded by the initials of the informant and date (in year.month.day format) in which they were obtained. Each row starts with:
–Column 1: number of the example cited in the text.
–Colum 2: video on which the sentence was signed (this is the video that informants assessed).
–Columns 3 and up: initials of the informant and date (in year.month.day format) on which the judgment was obtained, followed by the rating. Thus *[IH 12.07.19] = 2* means that a rating of 2 was obtained from Inf H on July 19, 2012.
On each row, ratings are arranged by informant, and within this category by chronological order. Each sequence of two or more ratings by an informant is followed by an average for this informant. Each row ends with an average per trial, followed by an average per informant if there were unequal numbers of trials per informant.

ASL ratings

														trial	subject
(6)a	8, 198	[JL 11.09.17] =	7	[JL 11.09.22] =	7	[JL 11.09.24] =	6	6.67							
(6)b	8, 200	[JL 11.09.17] =	7	[JL 11.09.22] =	6	[JL 11.09.24] =	5	6.00							
(6)a'	8, 198	[JL 11.09.17] =	6	[JL 11.09.22] =	6	[JL 11.09.24] =	6	6.00							
(6)b'	8, 200	[JL 11.09.17] =	7	[JL 11.09.22] =	7	[JL 11.09.24] =	6	6.67							
(7)a	8, 225	[JL 11.09.25] =	5	[JL 11.10.14] =	4	[JL 11.10.16] =	2	3.67	[I4 11.10.16] =	4	[I5 11.10.20] =	3	3.6	3.56	
(7)b	8, 225	[JL 11.09.25] =	4	[JL 11.10.14] =	4	[JL 11.10.16] =	1	3.00	[I4 11.10.16] =	3	[I5 11.10.20] =	2	2.8	2.67	
(8)a	8, 196	[JL 11.09.17] =	7	[JL 11.09.22] =	7	[JL 11.09.24] =	7	7.00					7	7.00	
(8)b	8, 196	[JL 11.09.17] =	7	[JL 11.09.22] =	7	[JL 11.09.24] =	7	7.00					7	7.00	
(8)c	8, 196	[JL 11.09.17] =	7	[JL 11.09.22] =	7	[JL 11.09.24] =	7	7.00					7	7.00	
(10)a	8, 225	[JL 11.09.25] =	7	[JL 11.10.14] =	7	[JL 11.10.16] =	7	7.00	[I4 11.10.16] =	6	[I5 11.10.20] =	6.5	6.7	6.50	
(10)b	8, 225	[JL 11.09.25] =	7	[JL 11.10.14] =	7	[JL 11.10.16] =	7	7.00	[I4 11.10.16] =	5	[I5 11.10.20] =	5.5	6.3	5.83	
(16)a	10, 128	[JL 12.05.14] =	7	[JL 12.05.23] =	7	7									
(16)b	10, 128	[JL 12.05.14] =	7	[JL 12.05.23] =	7	7									
(16)c	10, 128	[JL 12.05.14] =	7	[JL 12.05.23] =	7	7									
(17)a	11, 24	[JL 12.05.24] =	7												
(17)b	11, 24	[JL 12.05.24] =	7												
(17)c	11, 24	[JL 12.05.24] =	7												
(19)a	8, 17	[JL 11.08.19] =	7	[JL 11.12.19e] =	7	[JL 12.05.23]=	7	7.00							
(19)b	8, 17	[JL 11.08.19] =	6	[JL 11.12.19e] =	6	[JL 12.05.23]=	3	5.00							
(20)a	8, 12	[JL 11.08.19] =	7	[JL 11.12.19e] =	7			7.00							
(20)b	8, 12	[JL 11.08.19] =	6	[JL 11.12.19e] =	5			5.50							
(21)a	11, 26	[JL 12.05.24] =	7	[JL 12.07.23e] =	6	6.5									
(21)b	11, 26	[JL 12.05.24] =	5	[JL 12.07.23e] =	6	5.5									
(21)c	11, 26	[JL 12.05.24] =	2	[JL 12.07.23e] =	2	2									
(22)a	11, 27	[JL 12.05.24] =	7	[JL 12.07.23e] =	7	7									
(22)b	11, 27	[JL 12.05.24] =	6	[JL 12.07.23e] =	6	6									
(22)c	11, 27	[JL 12.05.24] =	3	[JL 12.07.23e] =	3	3									
(23)a	11, 28	[JL 12.05.24] =	2	[JL 12.07.23e] =	1	1.5									
(23)b	11, 28	[JL 12.05.24] =	6	[JL 12.07.23e] =	3	4.5									
(23)c	11, 28	[JL 12.05.24] =	7	[JL 12.07.23e] =	7	7									
(24)a1	8, 119	[JL 11.09.05] =	5	[JL 11.12.19e] =	5			5.00							
(24)a2	8, 119	[JL 11.09.05] =	7	[JL 11.12.19e] =	7			7.00							
(24)b1	8, 119	[JL 11.09.05] =	6	[JL 11.12.19e] =	6			6.00							
(24)b2	8, 119	[JL 11.09.05] =	6	[JL 11.12.19e] =	6			6.00							
(24)c1	8, 119	[JL 11.09.05] =	6	[JL 11.12.19e] =	7			6.50							

(24)c2	8, 119	[JL 11.09.05] =	6	[JL 11.12.19e] =	5			5.50						
(26)a	10, 42	[JL 12.05.11] =	7	[JL 12.05.23]=	5			6.00						
(26)b	10, 42	[JL 12.05.11] =	7	[JL 12.05.23]=	5			6.00						
(27)	10, 60	[JL 12.05.12] =	7	[JL 12.05.23]=	7			7.00						
(32)a	10, 66	[JL 12.05.12] =	3	[JL 12.05.23]=	3	[JL 12.05.29] =	3	3.00						
(32)b	10, 66	[JL 12.05.12] =	7	[JL 12.05.23]=	7	[JL 12.05.29] =	7	7.00						
(33)a	10, 68	[JL 12.05.12] =	7	[JL 12.05.23]=	7	[JL 12.05.29] =	7	7.00						
(33)b	10, 68	[JL 12.05.12] =	7	[JL 12.05.23]=	7	[JL 12.05.29] =	7	7.00						
(34)a	10, 64	[JL 12.05.12] =	4	[JL 12.05.23] =	2			3.00						
(34)b	10, 64	[JL 12.05.12] =	7	[JL 12.05.23] =	6			6.50						
(36)a1	10, 81	[JL 12.05.13] =	4	[JL 12.05.14] =	5	[JL 12.05.23] =	3		[JL 12.05.24] =	4	[JL 12.05.29] =	4	4	
(36)a2	10, 81	[JL 12.05.13] =	7	[JL 12.05.14] =	7	[JL 12.05.23] =	7		[JL 12.05.24] =	7	[JL 12.05.29] =	7	7	
(36)b1	10, 81	[JL 12.05.13] =	7	[JL 12.05.14] =	7	[JL 12.05.23] =	7		[JL 12.05.24] =	7	[JL 12.05.29] =	7	7	
(36)b2	10, 81	[JL 12.05.13] =	7	[JL 12.05.14] =	7	[JL 12.05.23] =	4		[JL 12.05.24] =	6	[JL 12.05.29] =	5	5.8	
(37)a1	10, 79	[JL 12.05.13] =	5	[JL 12.05.14] =	5	[JL 12.05.23] =	6		[JL 12.05.24] =	6	[JL 12.05.29] =	5	5.4	
(37)a2	10, 79	[JL 12.05.13] =	7	[JL 12.05.14] =	5	[JL 12.05.23] =	7		[JL 12.05.24] =	7	[JL 12.05.29] =	7	6.6	
(37)b1	10, 79	[JL 12.05.13] =	7	[JL 12.05.14] =	6	[JL 12.05.23] =	7		[JL 12.05.24] =	7	[JL 12.05.29] =	7	6.8	
(37)b2	10, 79	[JL 12.05.13] =	6	[JL 12.05.14] =	7	[JL 12.05.23] =	5		[JL 12.05.24] =	5	[JL 12.05.29] =	5	5.6	
(42)a1	10, 106	[JL 12.05.24] =	6	[JL 12.05.15] =	5	[JL 12.05.14] =	5	5.33						
(42)a2	10, 106	[JL 12.05.24] =	6	[JL 12.05.15] =	7	[JL 12.05.14] =	6	6.33						
(42)a3	10, 106	[JL 12.05.24] =	7	[JL 12.05.15] =	6	[JL 12.05.14] =	7	6.67						
(42)a4	10, 106	[JL 12.05.24] =	5	[JL 12.05.15] =	5	[JL 12.05.14] =	5	5.00						
(42)a5	10, 106	[JL 12.05.24] =	3	[JL 12.05.15] =	3	[JL 12.05.14] =	3	3.00						
(42)b1	10, 104	[JL 12.05.14] =	4	[JL 12.05.15] =	4	[JL 12.05.24] =	3	3.67						
(42)b2	10, 104	[JL 12.05.14] =	5	[JL 12.05.15] =	5	[JL 12.05.24] =	5	5.00						
(42)b3	10, 104	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.24] =	6	6.67						
(42)b4	10, 104	[JL 12.05.14] =	6	[JL 12.05.15] =	5	[JL 12.05.24] =	6	5.67						
(42)b5	10, 104	[JL 12.05.14] =	4	[JL 12.05.15] =	3	[JL 12.05.24] =	3	3.33						
(42)c1	10, 105	[JL 12.05.14] =	3	[JL 12.05.15] =	4	[JL 12.05.24] =	2	3.00						
(42)c2	10, 105	[JL 12.05.14] =	4	[JL 12.05.15] =	4	[JL 12.05.24] =	2	3.33						
(42)c3	10, 105	[JL 12.05.14] =	6	[JL 12.05.15] =	6	[JL 12.05.24] =	5	5.67						
(42)c4	10, 105	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.24] =	7	7.00						
(42)c5	10, 105	[JL 12.05.14] =	4	[JL 12.05.15] =	4	[JL 12.05.24] =	4	4.00						
(45)a1a	10, 110	[JL 12.05.14] =	1	[JL 12.05.15] =	3	[JL 12.05.24] =	2	2.00						
(45)a1b	10, 110	[JL 12.05.14] =	6	[JL 12.05.15] =	6	[JL 12.05.24] =	6	6.00						
(45)a2a	10, 110	[JL 12.05.14] =	2	[JL 12.05.15] =	4	[JL 12.05.24] =	3	3.00						
(45)a2b	10, 110	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.24] =	7	7.00						
(45)a3a	10, 110	[JL 12.05.14] =	1	[JL 12.05.15] =	2	[JL 12.05.24] =	1	1.33						
(45)a3b	10, 110	[JL 12.05.14] =	4	[JL 12.05.15] =	3	[JL 12.05.24] =	3	3.33						
(45)b1a	10, 111	[JL 12.05.14] =	1	[JL 12.05.15] =	2	[JL 12.05.24] =	1	1.33						
(45)b12	10, 111	[JL 12.05.14] =	5	[JL 12.05.15] =	5	[JL 12.05.24] =	3	4.33						
(45)b2a	10, 111	[JL 12.05.14] =	2	[JL 12.05.15] =	3	[JL 12.05.24] =	3	2.67						
(45)b2b	10, 111	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.24] =	7	7.00						
(45)b3a	10, 111	[JL 12.05.14] =	1	[JL 12.05.15] =	2	[JL 12.05.24] =	2	1.67						
(45)b3b	10, 111	[JL 12.05.14] =	5	[JL 12.05.15] =	4	[JL 12.05.24] =	5	4.67						
(45)c1a	10, 112	[JL 12.05.14] =	1	[JL 12.05.15] =	2	[JL 12.05.24] =	1	1.33						
(45)c1b	10, 112	[JL 12.05.14] =	3	[JL 12.05.15] =	3	[JL 12.05.24] =	2	2.67						
(45)c2a	10, 112	[JL 12.05.14] =	2	[JL 12.05.15] =	3	[JL 12.05.24] =	3	2.67						
(45)c2b	10, 112	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.24] =	7	7.00						
(45)c3a	10, 112	[JL 12.05.14] =	1	[JL 12.05.15] =	3	[JL 12.05.24] =	2	2.00						
(45)c3b	10, 112	[JL 12.05.14] =	7	[JL 12.05.15] =	6	[JL 12.05.24] =	6	6.33						
(49)a	8, 3	[JL 11.08.19] =	5.5	[JL 11.08.20] =	6	[JL 11.08.22] =	6		[JL 12.05.15] =	6			5.87 5	
(49)b	8, 3	[JL 11.08.19] =	2	[JL 11.08.20] =	2	[JL 11.08.22] =	3		[JL 12.05.15] =	3			2.5	
(50)a	10, 133	[JL 12.05.15] =	6	[JL 12.07.23e] =	7	6.5								
(50)b	10, 133	[JL 12.05.15] =	3	[JL 12.07.23e] =	5	4								
(53)1a	8, 322	[JL 11.10.17] =	3	[JL 12.07.23e] =	5	4								
(53)1b	8, 322	[JL 11.10.17] =	7	[JL 12.07.23e] =	7	7								
(53)1c	8, 322	[JL 11.10.17] =	6	[JL 12.07.23e] =	7	6.5								
(53)1d	8, 322	[JL 11.10.17] =	2	[JL 12.07.23e] =	3	2.5								

(53)2a	8, 322	[JL 11.10.17] =	7	[JL 12.07.23e] =	7	7
(53)2b	8, 322	[JL 11.10.17] =	4	[JL 12.07.23e] =	5	4.5
(53)2c	8, 322	[JL 11.10.17] =	2	[JL 12.07.23e] =	2	2
(53)2d	8, 322	[JL 11.10.17] =	1	[JL 12.07.23e] =	1	1
(54)1a	8, 320	[JL 11.10.17] =	5	[JL 12.07.23e] =	5	5
(54)1b	8, 320	[JL 11.10.17] =	6	[JL 12.07.23e] =	7	6.5
(54)1c	8, 320	[JL 11.10.17] =	7	[JL 12.07.23e] =	7	7
(54)1d	8, 320	[JL 11.10.17] =	3	[JL 12.07.23e] =	3	3
(54)2a	8, 320	[JL 11.10.17] =	7	[JL 12.07.23e] =	7	7
(54)2b	8, 320	[JL 11.10.17] =	4	[JL 12.07.23e] =	5	4.5
(54)2c	8, 320	[JL 11.10.17] =	2	[JL 12.07.23e] =	2	2
(54)2d	8, 320	[JL 11.10.17] =	1	[JL 12.07.23e] =	1	1
(55)1a	10, 116	[JL 12.05.14] =	6	[JL 12.05.15] =	7	[JL 12.05.23] = 6 6.33
(55)1b	10, 116	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.23] = 7 7.00
(55)1c	10, 116	[JL 12.05.14] =	7	[JL 12.05.15] =	6	[JL 12.05.23] = 6 6.33
(55)1d	10, 116	[JL 12.05.14] =	5	[JL 12.05.15] =	4	[JL 12.05.23] = 4 4.33
(55)1e	10, 116	[JL 12.05.14] =	3	[JL 12.05.15] =	2	[JL 12.05.23] = 2 2.33
(55)2a	10, 117	[JL 12.05.14] =	5	[JL 12.05.15] =	6	[JL 12.05.23] = 6 5.67
(55)2b	10, 117	[JL 12.05.14] =	6	[JL 12.05.15] =	6	[JL 12.05.23] = 6 6.00
(55)2c	10, 117	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.23] = 7 7.00
(55)2d	10, 117	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.23] = 6 6.67
(55)2e	10, 117	[JL 12.05.14] =	4	[JL 12.05.15] =	3	[JL 12.05.23] = 4 3.67
(57)1a	10, 118	[JL 12.05.14] =	2	[JL 12.05.15] =	2	[JL 12.05.23] = 3 2.33
(57)1b	10, 118	[JL 12.05.14] =	3	[JL 12.05.15] =	4	[JL 12.05.23] = 3 3.33
(57)1c	10, 118	[JL 12.05.14] =	4	[JL 12.05.15] =	7	[JL 12.05.23] = 6 5.67
(57)1d	10, 118	[JL 12.05.14] =	7	[JL 12.05.15] =	6	[JL 12.05.23] = 7 6.67
(57)1e	10, 118	[JL 12.05.14] =	6	[JL 12.05.15] =	3	[JL 12.05.23] = 5 4.67
(57)2a	10, 119	[JL 12.05.14] =	3	[JL 12.05.15] =	3	[JL 12.05.23] = 2 2.67
(57)2b	10, 119	[JL 12.05.14] =	4	[JL 12.05.15] =	3	[JL 12.05.23] = 2 3.00
(57)2c	10, 119	[JL 12.05.14] =	6	[JL 12.05.15] =	5	[JL 12.05.23] = 4 5.00
(57)2d	10, 119	[JL 12.05.14] =	7	[JL 12.05.15] =	7	[JL 12.05.23] = 7 7.00
(57)2e	10, 119	[JL 12.05.14] =	7	[JL 12.05.15] =	6	[JL 12.05.23] = 5 6.00
(60)1a	11, 99	[JL 12.06.02] =	6	[JL 12.07.23e] =	5	5.5
(60)1b	11, 99	[JL 12.06.02] =	7	[JL 12.07.23e] =	7	7
(60)1c	11, 99	[JL 12.06.02] =	2	[JL 12.07.23e] =	3	2.5
(60)2a	11, 100	[JL 12.06.02] =	3	[JL 12.07.23e] =	4	3.5
(60)2b	11, 100	[JL 12.06.02] =	7	[JL 12.07.23e] =	7	7
(60)2c	11, 100	[JL 12.06.02] =	6	[JL 12.07.23e] =	7	6.5

LSF ratings

										trial	subject
(11)a	22, 51	[IH 12.06.20] =	2	[IH 12.06.25] =	3	2.5	[IJ 12.07.06] =	1	2.00	1.75
(11)b	22, 51	[IH 12.06.20] =	6	[IH 12.06.25] =	5	5.5	[IJ 12.07.06] =	7	6.00	6.25
(11)c	22, 51	[IH 12.06.20] =	6	[IH 12.06.25] =	5	5.5	[IJ 12.07.06] =	7	6.00	6.25
(12)a	22, 55	[IH 12.06.20] =	6	[IH 12.06.25] =	6	6	[IJ 12.07.06] =	7	6.33	6.50
(12)b	22, 55	[IH 12.06.20] =	6	[IH 12.06.25] =	6	6	[IJ 12.07.06] =	7	6.33	6.50
(12)c	22, 55	[IH 12.06.20] =	4	[IH 12.06.25] =	5	4.5	[IJ 12.07.06] =	7	5.33	5.75
(13)	22, 59	[IH 12.06.20] =	6	[IH 12.06.25] =	6	6	[IJ 12.07.06] =	7	6.33	6.50
(28)a	21, 46	[IJ 12.05.22] =	6							
(28)b	21, 46	[IJ 12.05.22] =	7							
(28)c	21, 46	[IJ 12.05.22] =	6							
(29)a	22, 43	[IH 12.06.20] =	6	[IH 12.06.25] =	6		[IJ 12.07.06] =	5	5.67	5.00
(29)b	22, 43	[IH 12.06.20] =	6	[IH 12.06.25] =	5		[IJ 12.07.06] =	6	5.67	6.00
(29)c	22, 43	[IH 12.06.20] =	2	[IH 12.06.25] =	2		[IJ 12.07.06] =	3	2.33	3.00
(30)a	22, 45	[IH 12.06.20] =	2	[IH 12.06.25] =	2		[IJ 12.07.06] =	1	1.67	1.00
(30)b	22, 45	[IH 12.06.20] =	6	[IH 12.06.25] =	5		[IJ 12.07.06] =	3	4.67	3.00
(30)c	22, 45	[IH 12.06.20] =	6	[IH 12.06.25] =	6		[IJ 12.07.06] =	6	6.00	6.00

															trial	subject
(61)a1	19, 68	[IH 12.01.13] =	1	[IH 12.02.22] =	1	[IH 12.04.26] =	2	1.33	[IJ 12.03.09] =	4	[IJ 12.03.13] =	2	3.00	2	2.17
(61)a2	19, 68	[IH 12.01.13] =	7	[IH 12.02.22] =	5	[IH 12.04.26] =	6	6.00	[IJ 12.03.09] =	7	[IJ 12.03.13] =	7	7.00	6.4	6.50

(61)b1	19, 68	[IH 12.01.13] =	7	[IH 12.02.22] =	5	[IH 12.04.26] =	6	6.00	[IJ 12.03.09] =	7	[IJ 12.03.13] =	7	7.00	6.4	6.50
(61)b2	19, 68	[IH 12.01.13] =	3	[IH 12.02.22] =	1	[IH 12.04.26] =	5	3.00	[IJ 12.03.09] =	4	[IJ 12.03.13] =	2	3.00	3	3.00
(61)c1	19, 68	[IH 12.01.13] =	1	[IH 12.02.22] =	2	[IH 12.04.26] =	1	1.33	[IJ 12.03.09] =	1	[IJ 12.03.13] =	1	1.00	1.2	1.17
(61)c2	19, 68	[IH 12.01.13] =	1	[IH 12.02.22] =	1	[IH 12.04.26] =	1	1.00	[IJ 12.03.09] =	1	[IJ 12.03.13] =	1	1.00	1	1.00

(63)a1	20, 9	[IH 12.04.26] =	2	[IJ 12.03.13] =	2	2
(63)a2	20, 9	[IH 12.04.26] =	5	[IJ 12.03.13] =	6	5.5
(63)b1	20, 9	[IH 12.04.26] =	6	[IJ 12.03.13] =	7	6.5
(63)b2	20, 9	[IH 12.04.26] =	2	[IJ 12.03.13] =	4	3
(63)c1	20, 9	[IH 12.04.26] =	2	[IJ 12.03.13] =	3	2.5
(63)c2	20, 9	[IH 12.04.26] =	1	[IJ 12.03.13] =	1	1

(64)a1	20, 11	[IH 12.04.26] =	1	[IJ 12.03.13] =	1	1
(64)a2	20, 11	[IH 12.04.26] =	6	[IJ 12.03.13] =	7	6.5
(64)b1	20, 11	[IH 12.04.26] =	2	[IJ 12.03.13] =	4	3
(64)b2	20, 11	[IH 12.04.26] =	2	[IJ 12.03.13] =	5	3.5
(64)c1	20, 11	[IH 12.04.26] =	6	[IJ 12.03.13] =	7	6.5
(64)c2	20, 11	[IH 12.04.26] =	1	[IJ 12.03.13] =	1	1

(65)1a	23, 15	[IH 12.06.25] =	2	[IH 12.07.19] =	2	2
(65)1b	23, 15	[IH 12.06.25] =	3	[IH 12.07.19] =	4	3.5
(65)1c	23, 15	[IH 12.06.25] =	6	[IH 12.07.19] =	6	6
(65)2a	23, 14	[IH 12.06.25] =	6	[IH 12.07.19] =	6	6
(65)2b	23, 14	[IH 12.06.25] =	3	[IH 12.07.19] =	4	3.5
(65)2c	23, 14	[IH 12.06.25] =	2	[IH 12.07.19] =	2	2

(82)1a	23, 30	[IH 12.07.19] =	2	[IJ 12.07.06] =	1	1.5
(82)1b	23, 30	[IH 12.07.19] =	4	[IJ 12.07.06] =	5	4.5
(82)1c	23, 30	[IH 12.07.19] =	6	[IJ 12.07.06] =	7	6.5
(82)2a	23, 29	[IH 12.07.19] =	6	[IJ 12.07.06] =	7	6.5
(82)2b	23, 29	[IH 12.07.19] =	4	[IJ 12.07.06] =	4	4
(82)2c	23, 29	[IH 12.07.19] =	2	[IJ 12.07.06] =	1	1.5

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