Formal Indices and Iconicity in ASL[1]

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Abstract. Iconic constraints play an important role in the semantics of sign language in general, and of sign language pronominals in particular (e.g. Cuxac 1999, Taub 2001, Liddell 2003, Lillo-Martin and Meier 2011). But the field is sharply divided among two camps: (a) specialists of formal linguistics (e.g. Neidle et al. 2000, Lillo-Martin 1991, Sandler and Lillo-Martin 2006) primarily attempt to integrate sign language pronominals to universal models of anaphora, giving iconic phenomena a peripheral position; (b) specialists who emphasize the centrality of iconicity (e.g. Taub 2001, Liddell 2003) do so within informal frameworks that are not considered as sufficiently explicit by the formalist side. We attempt to reconcile insights from the two camps within a *formal semantics with iconicity* (Schlenker 2011a). We analyze three kinds of iconic effects: (i) *structural iconicity*, in which relations of embedding among loci are directly reflected in their denotations; (ii) *locus-external iconicity*, in which the high position of a locus in signing space has a direct semantic reflex; and (iii) *locus-internal iconicity*, where different parts of a structured locus are targeted by different directional verbs, as was argued by Liddell. We suggest that these phenomena can be understood if the interpretive procedure can, at the level of variables, impose an 'iconic mapping' between loci and the objects they denote.

Keywords: anaphora, sign language, logic, iconicity

1 Introduction: Sign Language Indexes as Formal Indices

In American Sign Language (ASL), the relation between a pronoun and its antecedent is often mediated by *loci*, which are positions in signing space that are usually associated with NPs (e.g. Sandler and Lillo-Martin 2006). A pronoun that depends on an NP will thus point towards the locus introduced by that NP, as in (1):[2]

(1)   a. IX-1 KNOW $_a$BUSH IX-1 KNOW $_b$OBAMA. IX-b SMART BUT IX-a NOT SMART.
       'I know Bush and I know Obama. He [= Obama] is smart but he [= Bush] is not smart.'
       b. 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.' (Inf 1, 4, 179)

Since there appears to be an arbitrary number of possible loci, it was suggested that the latter do not spell out morpho-syntactic features, but rather are the overt realization of 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.
–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] (Inf 1, 1, 108)

Still, an important fact has gotten in the way of an integration of sign language pronouns to the theories that were designed for spoken languages: sign language pronouns display numerous *iconic effects* that are absent from their spoken language counterparts. This has led some to take such a traditional grammatical approach to be hopeless (e.g. Liddell 2003). We will argue for a somewhat different position: iconic effects are real and central, but they can be integrated to a unified grammatical theory once we rethink some aspects of semantics and allow geometric considerations to play a central role in the meaning of variables. We analyze three kinds of iconic effects: (i) *structural iconicity*, in which relations of embedding among loci are directly reflected in their denotations; (ii) *locus-external iconicity*, in which the high position of a locus in signing space has a direct semantic reflex; and (iii) *locus-internal iconicity*, where different parts of a structured locus are targeted by different directional verbs, as was argued by Liddell 2003. We suggest that these phenomena can be understood if the interpretive procedure can, at the level of variables, impose an 'iconic mapping' between loci and the objects they denote.

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[2] ASL sentences are glossed in capital letters. Subscripts correspond to the establishment of positions ('loci') in signing space. Pronouns are usually realized through pointing towards a locus, and they are also glossed as *IX-a*, *IX-b*, etc. Parentheses starting with *Inf* refer to videos.

2 Complement Set Readings and Structural Iconicity

2.1 The phenomenon

We start with a type of iconicity which hasn't been much discussed in the sign language literature, but pertains to a traditional question in semantics: the availability of 'complement set' readings in examples such as (3)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 complement set.

(3)   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 (3)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 (3)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 (3)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 (3)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.

ASL signers can realize anaphora by using default loci (in front of the signers), or non-default ones. In the first case, English-style judgments can be replicated with maximal set anaphora (= (4)a-b) and restrictor set anaphora (=(4)a'-b').

(4)

a. 6.7 POSS-1 STUDENT FEW a-CAME CLASS.	b. 6 POSS-1 STUDENT MOST a-CAME CLASS.
'Few of my students came to class.'	'Most of my students came to class.'
IX-arc-a a-ASK-1 GOOD QUESTION	IX-arc-a a-ASK-1 GOOD QUESTION
'They asked good questions.'	'They asked good questions.'
a'. 6 POSS-1 STUDENT FEW a-CAME.	b'. 6.7 POSS-1 STUDENT IX-arc-a MOST a-CAME
'Few of my students came.'	CLASS.
	'Most of my students came to class.'
IX-arc-a NOT SERIOUS CLASS.	IX-arc-a SERIOUS CLASS.
'They are not a serious class.'	'They are a serious class.'
(Inf 1, 8, 198; 8, 199; 8, 204; 8, 222)	(Inf 1, 8, 200; 8, 201; 8 205; 8, 223)

(5)

POSS-1 STUDENT FEW a-CAME CLASS.	POSS-1 STUDENT MOST a-CAME CLASS.
a. 3.6 [3.6] IX-arc-a a-STAY HOME	b. 2.8 [2.7] IX-arc-a a-STAY HOME

Intended: 'Few/Most of my students came to class. They [the students that didn't come] stayed home.'
(Inf 1, 8, 225; 8, 226; 8, 285; 8, 300; 8, 305; 8, 348)

The high ratings in (4) were obtained from our main ASL consultant   (1 = worst, 7 = best; average score over 3 iterations on separate days).The crucial data are in (5): they involve complement set anaphora, and 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).

However, another anaphoric strategy can be used; 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]. Remarkably, this strategy automatically makes available a locus *A-a* for the complement set. As a result, all three readings become equally available, though with different indexings (importantly, all involve normal plural pronouns, and not the word *OTHER*). In (6), 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:

(6)   POSS-1 STUDENT IX-arc-ab MOST IX-arc-a a-CAME CLASS.
       'Most of my students came to class.' (Inf 1, 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 good questions.'
       c. 7 IX-arc-ab SERIOUS CLASS. 'They are a serious class.'

Data pertaining to complement set anaphora were also assessed in the same video as (5) (same 3 consultants); ratings confirm that with embedded loci complement set anaphora is acceptable ((7)b is similar to (6)a but was part of a different video):

(7)
   a. 6.7 [6.5] POSS-1 STUDENT IX-arc-ab FEW   b. 6.3 [5.8] POSS-1 STUDENT IX-arc-ab MOST
   IX-arc-a a-CAME. IX-arc-b b-STAY HOME   IX-arc-a a-CAME. IX-arc-b b-STAY HOME
   '(a) Few/ (b) Most of my students came to class. They [= the students who didn't come] stayed home.'
   (In 1, 8, 225; 8, 226; 8, 285; 8, 300 ; 8, 305; 8, 348)

2.2 An analysis with structural iconicity

To account for these data, 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)* becomes *ipso facto* available; (b) relations of inclusion and subtraction among loci are preserved by the interpretation function *via* constraints on assignment functions - an instance of 'structural iconicity'. Specifically:

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

In (4)-(7), we take the grammar to make available (i) a discourse referent for the maximal set and the restrictor set, but (ii) none for the complement set. When a default locus is used, ASL roughly behaves like English, and complement set anaphora is highly restricted (because of (ii)). In case embedded loci are used, ASL allows for complement set anaphora. Here is why: if *a* is a proper sublocus of a large locus *ab*, we can infer by (8)a(ii) that *(ab-a)* (i.e. *b*) is a locus as well; by (8)b(i), that s(a) $\subset$ s(ab); and by (8)b(ii), that s(b) = s(ab)-s(a). Complement set anaphora becomes available because ASL relies on an iconic property which is inapplicable in English.

3 High loci and locus-external iconicity

3.1 The phenomenon

In ASL, loci that are high in signing space can be used to refer to entities that are respectable, powerful, or tall – among others. This possibility is instantiated in (9), where a high locus *IX-a⁺* can be used to refer to the speaker's father (we do not have enough iterations of the judgment task to provide interesting numerical values; in cases of optionality, there is often a slight preference for the high locus):

(9)   MY FATHER IX-a⁺/IX-a (SELF-a⁺)³ BUSINESSMAN. IX-a⁺/IX-a RICH.
        'My father is a businessman. He is rich.' (Inf 1, 8, 17-18)

If the speaker intends to speak about his younger brother, the use of a high locus is dispreferred (hence *??* in (10)), unless he somehow wants to convey that his younger brother is more successful than him – in which case it is acceptable:

(10)   MY BROTHER ??IX-a⁺/IX-a (??SELF-a⁺)³ BUSINESSMAN. ??IX-a⁺/IX-a RICH
        Intended: 'My (younger) brother is a businessman. He is rich.' (Inf 1, 8, 19-20)

As can be seen in (11), reference to the government can also give rise to high loci:

(11)   EVERY ONE-arc / IX-arc GIVE-GIVE-a⁺/GIVE-GIVE-a MONEY GOVERNMENT
        IX-a⁺/IX-a. IX-arc-a⁺/IX-arc-a SHOULD RICH.
        'Everybody gives money to the government. They should be rich!' (Inf 1, 8, 12-13)

Finally, a similar phenomenon holds when one refers to tall people:

(12)   a. [EACH EACH GIANT GIANT GIANT]ₐ THINK NONE ONE LIKE IX-a⁺/IX-a.
        'Every giant thinks that nobody likes him.' (Inf 1, 8, 119e,f-120)
        b. [EACH EACH VERY TALL TALL TALL MAN]ₐ THINK NONE ONE LIKE IX-
        a⁺/IX-a.
        'Every very tall man thinks that nobody likes him.' (Inf 1, 8, 119c,d-120)

The word *GIANT* is produced high in signing space, hence the effect we see in (12)a could conceivably be morphological in nature. But this explanation won't carry over to (12)b: the word *MAN* is body-anchored, and hence does not introduce a locus of its own (unlike, say, the word for *ONE*, which is signed in a particular locus); furthermore, neither the sign for *VERY* nor the word for *TALL* is signed high. Nonetheless, use of a high locus is entirely natural, and appears to be licensed by semantic rather than by morphological considerations.

The examples in (12) make a further important point: use of high loci to refer to respectable, powerful or tall entities is by no means limited to deictic elements, since in these examples the pronouns are *bound* by universal quantifiers.

3.2 An analysis with iconic presuppositions

Following Lillo-Martin and Klima 1990, we take sign language indexes to be, in the cases under study, the overt realization of formal indices. Technically, we take assignment functions to assign values to loci as well as to standard (unpronounced) indices. For simplicity, we state our analysis in a framework in which gender features introduce presuppositions on the value of variables, as shown in (13)a:

(13)   Let c be a context of speech and s be an assignment function (c_a = the author of c).

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³*SELF-a⁺* was present in the 'high' version but not in the 'low' version.

a. If *f* is a feminine feature and *i* is in index, $[[\text{pro-f}_i]]^{f,s}$ = # iff s(i) = # or s(i) is not female. If $[[\text{pro-f}_i]]^{f,s}$ ≠ #, $[[\text{pro-f}_i]]^{f,s}$ = s(i).

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

(13)a states that a pronoun with feminine features *pro-f_i* yields a presupposition failure, i.e. denotes #, in case the assignment function s fails to assign to the formal index *i* a female individual. If no failure arises, *pro-f_i* denotes s(i). An analogous rule is stated in (13)b: 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. Needless to say, future research will have to refine the properties that appear in the part in bold in (13)b.

As stated, the rule in (13)b makes it an arbitrary fact that high loci, rather than low ones, say, carry the meanings at hand. 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). This iconic component is isolated in the following restatement of the rule:

(14)   If *i* is a locus that appears high in the signing space,
$[[\text{IX-i}]]^{f,s}$ = # iff s(i) = # or **<1, i> is not iconically projectable to <c_a, s(i)>** along the 'power', 'respectability' or 'height' dimension. If $[[\text{IX-i}]]^{f,s}$ ≠ #, $[[\text{IX-i}]]^{f,s}$ = s(i).

The new rule is identical to the old one, except that it makes an explicit provision for an iconic component, which establishes a connection between the geometric properties of the loci and some (real or metaphorical) properties of the objects they denote; as before, a detailed analysis of the expression in bold is left for future work.

3.3 Further application: deictic pronouns

When individuals are present in the discourse situation, one normally refers to them by pointing towards them. In other words, in such cases the locus must roughly correspond to the position of the person it denotes. The formalism we have just introduced can capture this fact:

(15)   If *i* is a locus, and if s(i) is present in the discourse situation, $[[\text{IX-i}]]^{f,s}$ = # iff s(i) = # or s(i) is present in the extra-linguistic situation and <1, i> is not iconically projectable to <c_a, s(i)> along the 'aligment' dimension. If $[[\text{IX-i}]]^{f,s}$ ≠ #, $[[\text{IX-i}]]^{f,s}$ = s(i).

In words: if s(i) is present in the discourse situation, then <1, i>, i.e. the pair of positions corresponding to the position of the signer and the locus *i,* must be aligned with <c_a, s(i)>, i.e. the pair of the signer and the denotation of *i*. 1 and c_a are roughly identical, hence when the signer points towards *i* he must also point towards s(i).

This rule has some bite: there are cases in which 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 *associated with that location*. This phenomenon, which we may call 'locative agreement', is illustrated in (16) (from Schlenker 2011a).

(16)   JOHN _a[WORK IX-a FRENCH CITY] SAME _c[WORK IX-c AMERICA CITY]. 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.'
(Inf 1, 4, 66b; Inf 1, 4 67 & 10.05.06, 10.05.11, Inf 1 7, 214, 7,234)

The lexical entry in (15) predicts that for deictic pronouns, this possibility should be precluded. See Schlenker 2011a for preliminary evidence that part of this prediction might be borne out in ASL.

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. Despite numerous disagreements, Liddell 2003 and Lillo-Martin and Meier 2011 both note that there are clear iconic effects with directional verbs, which *target different parts of a locus depending on their meaning* – e.g. 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'. How should this observation be incorporated into a formal theory?

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.

(17) (i) 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.'
      (ii) 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). The latter point strongly suggests that directional verbs can always license null pronouns, which in these cases behave like resumptive pronouns. This appears to argue for a grammatical theory, one in which directional verbs are an instance of anaphoric constructions. 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 argue 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 make reference to iconic requirement

4.2 Iconic effects with directional verbs

On an empirical level, we show (a) that Liddell's claims also hold of donkey and bound pronouns, and (ii) that the particular part of a locus which is targeted by agreement *depends on the position (upright or hanging) of the person referred to*.

Thus in (18)a, 8 sentences were rated in which (i) *ASK-QUESTIONS vs.* (ii) *COMMUNICATE-TELEPATHICALLY* were rated depending on the height of the loci they targeted. Preferred height was 'medium low' for (i) and 'high' for (ii) - and all examples involved 'donkey' pronouns, or rather agreement markers (7-point scale). In (18)b, a single directional verb was investigated, *ASK-QUESTIONS*. When its (existentially bound) direct object denoted a person *hanging* from a branch (roughly, with ⊤ , where horizontal = index of the non-dominant hand, and vertical = index+middle finger of the dominant hand), the position of the vertical that was preferably targeted was 'low'. When the object denoted a person *standing* on a branch (with ⊥), the position of the vertical that was preferably targeted 'high'. Importantly, in (18)b we only report ratings that concern *homogeneous* height assignments for the pronoun *IX-a* and for the target of *1-ASK-a*. Since our focus is on the latter, we leave further subtleties concerning the full pronoun for future research.[4]

(18)   a. Height differences

YESTERDAY [LINGUIST PERSON]$_a$ MEET [PHILOSOPHY PERSON]$_b$. THE-TWO-a,b
1. ASK-QUESTIONS-a,b
2. COMMUNICATE-BY-TELEPATHY-a,b (Inf 1, 8, 320-1)

Condition:	**1. ASK-a,b**	**2. COMMUNICATE-a,b**
a. high	5	7
b. medium high	6	4
c. medium low	7	2
d. low	3	1

'Yesterday a linguist met a philosopher. They 1. asked each other questions / 2. communicated by telepathy.'

b. The role of classifier position

Context: Several of my friends were hanging from a branch. TREE BRANCH APPROXIMATE CHEST-HIGH. SEVERAL POSS-1 FRIEND
1. HANG HANG HANG
2. STAND STAND STAND STAND   (Inf 1, 9, 8-10; 9, 9-11)
ONE$_a$ (IX-arc-a) a-TELL-1 IX-a WANT IX-1 1-ASK-QUESTIONS-a

Condition:	**1. Hanging**	**2. Standing**
a. High IX-a and a	3, 4	7, 7
b. Medium IX-a and a	5, 6	7, 7
c. Low IX-a and a	7, 7	2, 2

'There was a chest-high tree branch. Several of my friends were 1. hanging / 2. standing. One of them told me that he wanted me to ask him questions.'

The data in (18)a are just a replication of Liddell's observations. The data in (18)b show that it would be misguided to state a lexical entry in which the target of the movement is at different relative heights for different verbs: when the position of the classifier is reversed, from 'standing' to 'hanging', the preferred target of the movement is changed as well – preferably high in the 'standing' position and low in the 'hanging' position. This is entirely in line with Liddell's observation: one should view the locus which is targeted as a simplified picture of the person denoted; and since *ASK* targets the head of this person, it is only natural that it should be high in the 'standing' position and low in the 'hanging' condition. This appears to be a genuinely iconic effect, which ought to be captured by an appropriate formal semantic analysis.

4.3 An analysis with structured loci

Concentrating on directional verbs (rather than the pronouns they co-occur with), we propose an analysis which is based on two main ideas: (i) loci are structured, as Liddell claimed; (ii) the lexical semantics of directional verbs has an iconic component, which requires that the target of the movement should correspond to a

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[4] Some examples in (18)a2 might involve Role Shift, which should be better controlled for.

particular part of the object denoted by the locus. For simplicity, we implement this requirement in terms of a presuppositional semantics.

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

(19) Assignment functions assign values to **areas** of space ('area loci') rather than to **points** of space ('point loci'). Lower-case letters (e.g. i) designate point-loci; capital letters (e.g. I) designate area-loci;assignment functions assign values to variables and capital letters.

Our analysis posits that directional verbs have a presuppositional component. To illustrate it on a more familiar case, we use a toy example: we assume that person marking on verbs has a presuppositional semantics. On this view, *am-working* should give rise to a presupposition failure unless its argument denotes the speaker:

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

We posit a similar presuppositional semantics for directional verbs, but with an explicit iconic requirement (which for simplicity we take to hold of both arguments):

(21) For any objects x and y of type e, for any context c and assignment function s, $[[i\text{-ASK-QUESTIONS-}j]]^{f,s}(y)(x) = \#$ iff $x = \#$ or $y = \#$ or $s(J) \neq y$ or $s(I) \neq x$ or $<I, i>$ is not iconically projectable to $<body(s(I)), \boxed{chin(s(I))}>$ along the 'position' dimension or $<J, j>$ is not iconically projectable to $<body(s(J)), \boxed{chin\ (s(J))}>$ along the 'position' dimension. If $\neq \#$, $[[i\text{-ASK-QUESTIONS-}j]]^{f,s}(y)(x) = 1$ iff x ask questions to y.

In words: when *i-ASK-QUESTIONS-j* is a movement from a point i of an area locus I to a point j of an area locus J; a failure is obtained unless i is with respect to I in the same position as the chin of s(I) with respect to the body of s(I); we abbreviate this as: $<I, i>$ is not iconically projectable to $<body(s(I)), chin(s(I))>$ along the 'position' dimension. The same condition holds of j, J. Needless to say, this characterization is just a placeholder for a properly geometric analysis; our goal at this point is just to indicate where in the interpretive procedure this condition plays a role.

For *COMMUNICATE-BY-TELEPATHY*, the rule is the same, except that (i) there is no temporal asymmetry between i, j (both are targeted at the start) and (ii) the part of the structured locus which is targeted is the forehead rather than the chin.

(22) For any objects x and y of type e, for any context c and assignment function s, $[[i\text{-}j\text{-COMMUNICATE-BY-TELEPATHY}]]^{f,s}(y)(x) = \#$ iff $x = \#$ or $y = \#$ or $s(J) \neq y$ or $s(I) \neq x$ or $<I, i>$ is not iconically projectable to $<body(s(I)), \boxed{forehead(s(I))}>$ along the 'position' dimension or $<J, j>$ is not iconically projectable to $<body(s(J)), \boxed{forehead(s(J))}>$ along the 'position' dimension. If $\neq \#$, $[[i\text{-}j\text{-COMMUNICATE-BY-TELEPATHY}]]^{f,s}(y)(x) = 1$ iff x communicates by telepathy with y.

To illustrate, consider the sentence *John asks me questions*, i.e. *JOHN i-ASK-QUESTIONS-k Ø_k*, with *k* targeting the signer. At the first step of the semantic derivation, we just 'feed' the verb its arguments. *JOHN* denotes the individual John, and $Ø_k$ denotes whatever the assignment function specifies that the area-locus K denotes – in this case, the signer, hence $s(K) = c_a$. Thus we have the step in (23):

(23) $[[JOHN\ i\text{-ASK-QUESTION-}k\ Ø_k]]^{f,s} = [[\ i\text{-ASK-QUESTION-}k]]^{f,s}\ ([[Ø_k]]^{f,s})([[JOHN]]^{f,s}) = [[i\text{-ASK-QUESTION-}k]]^{f,s}(s(K))(John) = [[i\text{-ASK-QUESTION-}k]]^{f,s}(c_a)(John)$

We can now apply the lexical entry in (21), with $y = c_a$ and $x =$ John. It is immediate that $x \neq \#$ and $y \neq \#$, and by assumption $s(K)$ is the signer c_a. Taking these facts into account, we derive the desired presupposition, i.e. that *ASK-QUESTIONS* targets what corresponds to the 'chin' position of the signer (as well as of I):

(24) $[[\text{JOHN i-ASK-QUESTIONS-k } \emptyset_k]]^{f, s} = \#$ iff $[[\text{i-ASK-QUESTION-k}]]^{f, s}(c_a)(\text{John}) = \#$, iff $<K, k>$ is not iconically projectable to $<\text{body}(c_a), \text{chin}(c_a)>$ along the 'body' dimension or $<I, i>$ is not iconically projectable to $<\text{body}(j), \text{chin}(j)>$ along the 'body' dimension.

When this presupposition is satisfied, we derive the desired truth conditions:

(25) If $[[\text{JOHN i-ASK-QUESTIONS-k } \emptyset_k]]^{f, s} \neq \#$, $[[\text{JOHN i-ASK-QUESTION-k } \emptyset_k]]^{f, s} = 1$ iff $[[\text{i-ASK-QUESTION-k}]]^{f, s}(c_a)(\text{John}) = 1$, iff John asks questions to c_a.

In conclusion, we hope to have shown that a formal semantics with iconicity holds good promise for the analysis of sign language anaphora, in particular of complement set readings, high loci, and directional verbs. The key idea is that in the end loci are *both* variables (or discourse referents) and simplified pictures of what they denote.

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