Discourse anaphora – theoretical perspectives

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1 Setting the stage

The study of pronouns and anaphora has been integral to the study of formal semantics, giving a variety of insights into the logic underlying natural language. In the values that they can take, pronouns reveal the primitive semantic objects that natural language can make reference to. In the long-distance logical relationship that holds between a pronoun and its antecedent, they give insight into the architecture of the compositional system.

The sign language modality provides unique advantages to the study of pronouns and discourse anaphora. Most notably, through the use of space, many sign languages allow the connection between a pronoun and its antecedent to be made phonologically overt: noun phrases (e.g. *John*, *someone*, ...) may be placed at locations in space ('loci'); pronouns then can refer back to an antecedent by literally pointing at the locus where the antecedent was indexed. As a result, sentences that would be ambiguous in spoken language can be disambiguated in sign language. Example (1) provides a simple example.[1]

(1) **ASL**
JOHN$_a$ TELL BILL$_b$ IX-a WILL WIN.
a. = 'John told Bill that John will win.'
b. ≠ 'John told Bill that Bill will win.'

In (1), the pronoun points to the locus that was established by JOHN; thus, unlike the parallel English example ('John told Bill that he would win'), the pronoun unambiguously refers to John. Replacing IX-a with IX-b results in the opposite interpretation.

[1]Glossing conventions: signs from all sign languages will be glossed with their closest English translation in small caps. The three pronominals discussed include IX (a pronoun, short for 'index'), SELF (a reflexive), and

Rich semantic theories have been built to account for discourse anaphora in spoken language, encompassing quantificational binding within a single sentence and 'dynamic binding' across sentences. In this chapter, I will discuss the sign language contributions to these theories. As we will see, data from sign language will bear on a number of classic and recent debates, including variable-ful vs. variable-free meanings for pronouns and E-type theories vs. dynamic theories for cross-sentential binding. The sign language data will also motivate new questions about the semantic system, in particular with respect to the status of iconic forms within the formal grammar.

The chapter is laid out as follows:

Section 2 establishes that pronouns in sign language and spoken language are fundamentally part of the same abstract pronominal system, an essential step if we wish to use data from one modality to bear on the other. Of particular semantic note, we review a wide literature showing that bound readings of pronouns have been established across many sign languages. More generally, we are left with quite a robust generalization that, modulo the use of space, patterns of pronouns in sign language are exactly like those we are familiar with from spoken language.

Grounded on the finding that sign language pronouns should be analyzed within the same system as spoken language pronouns, Section 3 asks how the use of space should be incorporated into these formal models. We review both variable-based and feature-based approaches to the use of space, concluding that loci must be at least partially featural in nature. We then turn to the iconic use of space. While iconicity is present to a limited extent in spoken languages, the visual modality provides a much richer domain in which to test how iconic information is incorporated into a logical grammar.

Perhaps the largest theoretical shift in semantic theory has been to the shift towards theories of Dynamic Semantics (broadly construed, which I take to subsume Discourse Representation Theory as well), in which sentence meanings are conceptualized not as static forms with truth conditions, but as dynamic operations that change the discourse context itself (Kamp 1981, Heim 1982, Groenendijk and Stokhof 1991, Dekker 1993, Muskens 1996). In Section 4, we turn to sign language contributions to debates about dynamic semantics.

2 The same system

A precondition for using sign language data to bear on theories of pronouns for spoken language—or vice versa—is establishing that pronouns in sign language and pronouns in spoken language are indeed part of the same abstract pronominal system. In this section, we show that this is the case, summarizing descriptive work of the syntax and semantics of pronouns. It is important to note that, given the similarity of the sign IX to pointing gestures that can co-occur with spoken language, this answer is by no means obvious *a priori*. Yet, this is indeed what we find, in quite

POSS (a possessive). Lower-case letters appended to signs will be used to indicate locations in space.

Abbreviation conventions: ASL = American Sign Language, LSF = French Sign Language, LIS = Italian Sign Language, RSL = Russian Sign Language, DGS = German Sign Language, LSC = Catalan Sign Language.

a compelling form: modulo the use of space, pronouns in sign language show exactly the same complex patterns as we see in spoken language.

2.1 Syntax

Syntactically, pronouns in spoken language are characterized by a range of constraints on distribution and co-reference. These include Binding Theory conditions, crossover effects, and resumptive uses for island extraction. Each of these patterns has been shown to be attested in some form in sign languages.

Conditions A and B are generalizations about the distribution of pronouns (*he* and *him* in English) and anaphors (*himself* in English). Broadly speaking, pronouns cannot be bound by an NP in the same local domain (Condition B); anaphors must be (Condition A). Sandler and Lillo-Martin 2006 and Koulidobrova 2009 show that related generalizations hold for the pronominals IX and SELF in ASL. The constraints on the reflexive SELF in subject position are weaker than in English, but Koulidobrova 2009 argues that cases of 'non-local binding' are in fact due to local binding by a null pronoun, evidenced in part by a marked, 'intensive' interpretation.

(2) **Condition B in ASL**

a. * JOHN$_a$ LIKES IX-a.

b. JOHN$_a$ LIKES SELF-a.
'John likes himself.'

(3) **Condition A in ASL** (Koulidobrova 2009)

a. MARY$_a$ THINK JOHN$_b$ KNOW PEDRO$_c$ LIKE SELF-$\{$*a,*b,c$\}$.
'Mary thinks John knows Pedro likes himself.'

In general, a binder must appear at a structurally higher position than the pronoun it binds. 'Crossover' (both strong and weak) describes the fact that this cannot be resolved by movement of the binder to a higher node, as in *wh*-question formation. For example, note that in the spellout of the English sentence in (4), the NP *which boy* linearly precedes and is structurally higher than the pronoun *he*, yet still cannot bind it.

(4) Which boy did he think __ would win?
Unavailable reading: 'Which boy x is such that x thought that x would win?'

Similar results have been shown to hold for sign language. Lillo-Martin 1991, Sandler & Lillo-Martin 2006, and Schlenker and Mathur 2013 report crossover effects for ASL; Santoro & Geraci 2013 report similar facts for LIS. An example with *wh*-movement is given in (5). (Here, the sentence is ungrammatical because the spatial coindexation of WHO and IX focuses interpretation on the unavailable reading.)

(5) **ASL** (Schlenker and Mathur 2013)

* WHO-CL-a IX-a THINK MARY LOVE __ NO-MATTER WHAT?
'Who does he think Mary will love __ no matter what?'
Intended: 'Which person x is such that x thinks that Mary loves x no matter what?'

In spoken languages like English, there are syntactic constraints against extracting a noun phrase from certain structural positions. However, in many languages, adding a pronoun at the extraction site often has the effect of rescuing the grammaticality of the sentence. In such cases, the pronoun is called a resumptive pronoun. What makes this phenomenon particularly interesting is the fact that the semantic meaning of the resumptive pronoun and the gap are identical (roughly speaking, a bound variable).

The sentences in (6) provide an example from Hebrew, where a preposition cannot be stranded without a resumptive pronoun.

(6) **Hebrew** (Sharvit 1999)

a. * ha- iSa Se dibarnu al __ higia.
the- woman Op we-talked about __ arrived

b. ha- iSa Se dibarnu ale- ha higia.
the- woman Op we-talked about her arrived
'The woman we talked about arrived.'

In sign languages, too, there are structural constraints on extraction. Notably for us, Lillo-Martin 1986 shows that the pronoun IX can be used resumptively in ASL: the pronoun in (7a) rescues the grammaticality of (7b). Schlenker and Mathur 2013 present tentative evidence that pronouns may also behave resumptively to save cases of crossover generated by *wh*-movement.

(7) **ASL** (Lillo-Martin 1986)

a. $\overline{[\text{THAT COOKIE}]_a}^{\text{top}}$, IX-1 HOPE SISTER$_b$ SUCCEED $_b$PERSUADE$_c$ $_c$MOTHER EAT IX-a.

b. * $\overline{[\text{THAT COOKIE}]_a}^{\text{top}}$, IX-1 HOPE SISTER$_b$ SUCCEED $_b$PERSUADE$_c$ $_c$MOTHER EAT __.
'That cookie$_i$, I hope my sister manages to persuade my mother to eat it$_i$.'

Koulidobrova 2012 provides evidence that this might not be the whole story for ASL: in particular, for some ASL signers who report the contrast in (7), the sentence in (7b) also becomes grammatical if the noun phrase 'THAT COOKIE' is signed at a neutral location in space. What is relevant now for our generalizations about pronouns is the fact that, in those cases where extraction *is* prohibited, a resumptive pronoun can often rescue grammaticality.

In sum, sign language pronouns show binding conditions, crossover effects, and resumptive effects.

2.2 Semantics

Semantically, perhaps the most notable property of pronouns is that they can be bound: they need not always receive a fixed value, but can vary in the scope of another operator. In the English sentence in (8), the pronoun *his* does not pick out a single individual (either atomic or plural); instead, it varies in value with respect to individuals quantified over by the quantifier phrase *every boy*. This property of **co-variation** with a higher operator is the hallmark of a bound reading.

(8) Every boy saw his mother.

In sign language, can pronouns be bound? Here, I report findings that show the answer to be 'yes': bound readings are attested robustly across the literature and across many sign languages (ASL, LSF, LIS, DGS, and RSL, to name a few). These results conclusively show that the semantic analysis of pronouns in sign language must be fundamentally the same as pronouns in spoken language. This is in contrast to purely referential analyses that have been proposed for pointing gestures that accompany spoken language (Giorgolo 2010).

The empirical situation in sign language is somewhat more complicated; in particular, sign languages sometimes do not allow bound readings in environments where spoken languages do (Graf and Abner 2012; Koulidobrova and Lillo-Martin (to appear)). Here, I leave the explanation for these differences largely open.

Bound readings can be seen in a wide variety of structures; these include: variation under individual quantifiers like *every* and *no*, variation under temporal quantifiers like *whenever*, variation of focus alternatives under *only*, and sloppy readings under ellipsis.

Kuhn 2015a confirms that pronouns can be bound under ALL in ASL, as in (9).

(9) [ALL BOY]$_a$ WANT [ALL GIRL]$_b$ THINK IX-a LIKE IX-b.
'All the boys want all the girls to think they like them.'

Kuhn 2015a verifies with interpretation questions that the pronoun is truly receiving a bound reading, evidenced by co-variation. In particular, (9) has a reading in which each boy wants each girl to think that he likes her (as distinct from a reading where the sum of the boys likes the sum of the girls). This replicates data from Graf and Abner 2012 that pronouns can be bound under ALL and EACH in ASL.

'Donkey sentences,' as discussed in Schlenker 2011, provide an example where pronouns co-vary in the scope of a temporal quantifier. In the LSF sentence in (10), the value of the pronoun IX depends on which 'donkey-owning' situation is being considered (by the temporal quantifier WHEN).[2]

(10) **LSF** (Schlenker 2011)

[2]These examples also play an important role in the theory of dynamic semantics; we will return to these arguments in §4.

EACH-TIME LINGUIST$_a$ PSYCHOLOGIST$_b$ THE-THREE-a,b,1 TOGETHER WORK, IX-a HAPPY BUT IX-b HAPPY NOT.
'Whenever I work with a linguist and a psychologist, the linguist is happy but the psychologist is not happy.'

Schlenker 2011 reports these results for ASL and LSF; Kuhn 2015a replicates these patterns for ASL. Steinbach and Onea 2015 report analogous results for DGS.

In verb phrase ellipsis, the site of ellipsis must retrieve a predicate of type $\langle e, t\rangle$ from an overt VP in the context. When a pronoun appears in this overt VP, the meaning of the ellipsis site depends on whether the overt pronoun was bound or free, generating an ambiguity: 'strict' readings arise from the ellipsis of a free pronoun; 'sloppy' readings arise from the ellipsis of a bound pronoun. Example (11) provides provides an example with two different LFs that could be retrieved.

(11) Teresa saw her mother. Becky did ___, too.

a. *Strict reading:* 'Becky saw Teresa's mother.'
VP meaning: $\lambda x[x$ saw y_{Teresa}'s mother$]$

b. *Sloppy reading:* 'Becky saw Becky's mother.'
VP meaning: $\lambda x[x$ saw x's mother$]$

Note that on the sloppy reading, we essentially have covariation over a domain of two: Teresa and Becky. The presence of sloppy readings can therefore be used as another diagnostic for bound pronouns.

Sloppy readings of pronouns have been widely reported in the sign language literature. Lillo-Martin and Klima 1990 (among others) report strict/sloppy ambiguity for ASL. Analogous findings have been reported for many other sign languages, including LSF (Schlenker 2011) and LIS (Cecchetto et al. 2015). Examples are given here for ASL and LIS.

(12) **ASL** (Lillo-Martin and Klima 1990)
MARY$_a$, ALICE$_b$. IX-a THINK IX-a HAVE MUMPS. IX-b SAME.

a. 'Mary thinks she has mumps. Alice ⟨thinks Mary has mumps⟩, too.'

b. 'Mary thinks she has mumps. Alice ⟨thinks Alice has mumps⟩, too.'

(13) **LIS** (Cecchetto et al. 2015)
GIANNI$_a$ SECRETARY POSS-a VALUE. PIERO SAME.

a. 'Gianni values his secretary. Piero ⟨values Gianni's secretary⟩, too.'

b. 'Gianni values his secretary. Piero ⟨values Piero's secretary⟩, too.'

Finally, under focus sensitive operators like *only*, pronouns that are co-referent with an NP in focus may be bound or free, creating an ambiguity analogous to that of ellipsis constructions. For example, sentence (14) entails that Alice has a property that holds of no other individuals in context. On the bound reading, the pronoun *her* co-varies with respect to these focus alternatives.

(14) Only Alice$_F$ saw her mother.

a. *Free reading:* 'No other people saw Alice's mother.'

b. *Bound reading:* 'No other people saw their own mother.'

Kuhn 2015a reports that analogous ambiguities exist for several signers of ASL. Schlenker 2014 reports similar results for both ASL and LSF.

(15) **ASL** (Kuhn 2015a)
IX-a JOHN$_{\text{a}}$ ONLY-ONE SEE POSS-a MOTHER.

a. John saw his mother and no other people saw John's mother.

b. John saw his mother and no other people saw their own mother.

Thus, as evidenced by examples with individual quantifiers, temporal quantifiers, ellipsis constructions, and focus alternatives, pronouns in sign language can be bound.

If I have been somewhat pedantic in enumerating examples of bound readings in sign language, it is because there are a number of examples where bound readings are dispreferred or impossible in sign language where they are perfectly available in spoken language. Two such examples are mentioned here. First, Graf and Abner report that some signers find it difficult for a pronoun to be bound under the quantifier NONE. They report the following data.

(16) **ASL** (Graf and Abner 2012)
* [NO POLITICS PERSON]$_{\text{a}}$ TELL-STORY IX-a WANT WIN.
Intended: 'No politician said that he wanted to win.'

Kuhn 2015a reports a split in judgments on similar sentences, with some signers finding analogous constructions acceptable under the bound reading.

Second, bound readings have been reported not to exist on pronouns that have not had an antecedent introduced at a specific locus. Koulidobrova and Lillo-Martin (to appear) report the following paradigm.

(17) **ASL** Koulidobrova and Lillo-Martin (to appear)

a. BOY ALL THINK {IX-a,c/IX-neutral} SMART.
'All the boys$_i$ think they$_{j/*i}$ are smart'

b. PETER THINK {IX-a/IX-neutral} SMART, JOHN$_{\text{b}}$ SAME.
'Peter$_i$ thinks he$_{j/*i}$ is smart; John$_k$ does too'
= Peter and John think someone else is smart

I think it is still an open puzzle what exactly is going on in these cases, but I take the litany of examples above as convincing evidence that exceptions should be captured through constraints (perhaps presuppositions) on a system otherwise identical to spoken language.

Finally, while I have tried to make the case that bound readings of pronouns exist across many sign languages, it is fully possible that exceptional languages exist. For instance, in Katak Kolek, a sign language used in a small village north of Bali, Indonesia, Perniss and Zeshan 2008 report that pronouns always point to the real-world locations of their referents or to some object associated with their referent. No data is given about how signers of Katak Kolek express meanings generally communicated through bound readings, but it is nevertheless conceivable that Katak Kolek has a fundamentally different pronominal system than the spoken languages or sign languages reviewed above.

2.3 Summary: pronouns in sign language and spoken language

In summary, systems of sign language pronouns, cross-linguistically, fit into the same formal patterns that are well known and established for spoken language pronouns. Syntactically, they reflect Binding Theory conditions, they show crossover effects, and they can be used resumptively to rescue island violations. Semantically, they can be bound or free, giving rise to ambiguities like strict and sloppy readings under ellipsis. We conclude that pronouns in sign language and pronouns in spoken language are reflections of the same abstract pronominal system.

3 How is space encoded?

At this point, we have established that pronouns in sign languages are fundamentally part of the same abstract system as pronouns in spoken language, allowing, in the base case, the same expressive possibilities (e.g. bound readings) and subject to the same kinds of structural constraints (e.g. Binding Theory).

But, as has been widely noted in the literature, sign language pronouns are unique in that they can be disambiguated with the use of space, as we saw in example (1), repeated here.

(18) **ASL**

JOHN$_a$ TELL BILL$_b$ IX-a WILL WIN.

a. $=$ 'John told Bill that John will win.'

b. $\neq$ 'John told Bill that Bill will win.'

These uses of space display two properties in particular that make them unique. First, there are theoretically infinitely many possible loci; Lillo-Martin and Klima 1990 emphasize this point, noting that even though psychological constraints prevent more than a few loci from being used in a particular discourse, for any two loci, a third locus can be established between them. Second, there is an arbitrary relationship between a given noun phrase and the locus where it is assigned. That is, in one discourse, a particular noun phrase might be assigned one locus; in another discourse, it might be assigned a different locus. Thus, the factors that determine locus placement are not intrinsic to the noun phrase in question; instead, they are determined by a collection of pressures, including the number of referents, the order in which

they are mentioned, and phonological constraints. (For more discussion of locus placement, see Geraci 2014, who argues that the default placement of loci in LIS reflects position in the syntactic hierarchy.)

In spoken language, there seems to be no analogous phonetic marker with these properties that holds the same syntactic status in being able to disambiguate logical forms. For example, no spoken language can arbitrarily place pitch contours on a noun phrase as a unique designator that can be repeated later on a pronoun that refers to it. (On the other hand, see Aronoff et al. 2005 for discussion of 'alliterative agreement' in Bainouk an Arapesh, which arguably reflects a theoretically unbounded feature set.)

Given the results discussed in §2, we have argued that sign language pronouns and spoken language pronouns should be analyzed within the same basic framework. How, then, do we encode the use of space into this framework?

Two basic answers have been proposed for this question. The first principal line of analysis follows Lillo-Martin and Klima 1990, who propose that loci are an overt phonological reflection of syntactic indices, or, in semantic terms, variable names. The second principal line of analysis (Neidle et al. 2000, Kuhn 2015a, Steinbach and Onea 2015) posits that loci are a kind of syntactic feature—albeit one with the unusual properties described above.

Here, following Kuhn 2015a, I will argue that compelling parallels exist between loci in sign language and morphosyntactic features in spoken language, several of which cannot be captured in a purely variable-based analysis. These include the following facts:

1. In appropriate contexts, multiple distinct noun phrases can be indexed at the same locus, just as multiple noun phrases in spoken language can bear the same feature.

2. Loci on pronouns may be *uninterpreted* in exactly the same contexts where morphosyntactic features are uninterpreted in spoken language—namely, in sites of ellipsis and under focus-sensitive operators.

3. Loci induce changes on verbal morphology in a way parallel to feature agreement or clitic incorporation (ASL: Lillo-Martin and Meier 2011, among others).

4. Loci show patterns of underspecification similar to syncretisms familiar from spoken language (ASL: Kuhn 2015a, DGS: Steinbach and Onea 2015).

In this section, I focus primarily on the first two of these properties, which pose challenges for the variable-based analysis.

3.1 Variables or features?

Lillo-Martin and Klima (1990) observe that there are a number of striking parallels between loci and formal variables: in both cases, they appear on a pronoun and its antecedent, there are unboundedly many of them, and they disambiguate pronouns under multiple levels of embedding. Inspired by this wealth of similarities, Lillo-Martin and Klima propose that loci are an overt phonological reflection of variable names.

On the other hand, a rich thread of semantic work argues that the logic underlying natural language does not make use of formal variables (e.g., Quine 1960, Szabolcsi 1987, Jacobson 1999). Grounding for this hypothesis arises from the fact that variables are not logically necessary for expressive purposes; for example, Curry and Feys 1958 show that any Turing-complete language can be translated into Combinatory Logic, which makes no use of variables. There is thus a theoretical tension between theories of semantics that say that variables don't exist, and analyses of sign language that say that say that loci *are* them.

From another point of view, the Curry-Feys isomorphism is a sword that cuts both ways: anything that is expressible without variables can also be expressed with variables. The question, then, is a syntactic one: which semantic theory is a better match for the compositional system that we see in natural language? This formulation in fact reflects the discussion of Lillo-Martin and Klima 1990, who draw a distinction between the linguistic object—the locus—and the syntactic object—the index. The question about loci can thus be reformulated: to what extent do these linguistic objects—loci—seem to have the formal properties of variables?

Kuhn 2015a approaches this problem by laying out a strong instantiation of a variable-based hypothesis side by side with the hypothesis in which loci are analyzed as a morphosyntactic feature, akin to phi-features in English (Neidle et al. 2000). The two hypotheses can be stated as follows:

(19) **The (strong) loci-as-variables hypothesis:** There is a one-to-one correspondence between ASL loci and formal variables.

(20) **The loci-as-features hypothesis:** Different loci correspond to different values of a morphosyntactic spatial feature.

(Kuhn 2015a)

Kuhn 2015a isolates the following property that critically distinguishes the two hypotheses: two variables of the same name that are unbound in a particular constituent must receive the same interpretation; in contrast, two pronouns that are unbound in a particular constituent may bear the same feature yet receive different interpretations.

This difference is exemplified by the examples in (21). In both sentences, the two pronouns are unbound in the bracketed constituent. In (21a), the two pronouns both bear the feature [+masc], but can receive distinct interpretations, yielding a meaning where the cat and the dog have different owners. On the other hand, in (21a), the two pronouns are both interpreted as the same variable; they must therefore pick out the same individual.

(21) a. John told Barry that [his$_{[+\text{masc}]}$ cat scratched his$_{[+\text{masc}]}$ dog].
b. John told Barry that [his$_x$ cat scratched his$_x$ dog].

These facts make predictions about loci in ASL. A featural analysis predicts that two pronouns that are unbound in the same constituent can share the same locus yet receive different interpretations; a variable-based analysis predicts that they cannot.

Kuhn 2015a argues that it is possible to find cases where two pronouns are indexed at the same locus but nevertheless receive different interpretations, thus falsifying the strong loci-as-variables hypothesis. Two kinds of examples form the core of the argument. First, we

consider cases where two referential NPs at the same locus serve as potential antecedents for later pronouns. The acceptability of such sentences seems to be dependent on a number of pragmatic factors, but improves when context and world-knowledge sufficiently disambiguate the sentence (so that space doesn't have to). The sentence is judged as acceptable (on a seven-point scale, reliably at 6/7); critically, the sentence entails that John tells Mary that he loves her (or, dispreferred by world knowledge, that she loves him). The two pronouns are co-located but not co-referential.

(22) **ASL** (Kuhn 2015a)
EVERY-DAY, JOHN$_{\text{a}}$ TELL MARY$_{\text{a}}$ IX-a LOVE IX-a. BILL$_{\text{b}}$ NEVER TELL SUZY$_{\text{b}}$ IX-b LOVE IX-b.
'Every day, John$_i$ tells Mary$_j$ that he$_i$ loves her$_j$. Bill$_k$ never tells Suzy$_l$ that he$_k$ loves her$_l$.'

In a second class of examples, two pronouns appear at the locus of an NP modified by ONLY-ONE. As discussed above, under focus sensitive operators like *only*, pronouns that are co-referent with the focused NP may be bound or free. In sentences with two pronouns, then, four readings are logically possible; either pronoun can be bound and either can be free.[3] Sentence (23) tests what happens in sign language; here, note that there is no question that there is only a single locus involved, since there is only one NP introducing locus b. Kuhn 2015a reports a context-matching task that shows that this sentence is ambiguous in ASL, just as in English. To highlight one of the mixed readings, the context for the 'free-bound' reading is provided in (24).

(23) **ASL** (Kuhn 2015a)
IX-a JESSICA TOLD-ME IX-b BILLY ONLY-ONE FINISH-TELL POSS-b MOTHER POSS-b FAVORITE COLOR.
'Jessica told me that only Billy told his mother his favorite color.'
Can be read as: *bound-bound, bound-free, free-bound, or free-free.*

(24) ***Free-bound:*** [Only Billy$_x$] $\lambda y.y$ told x's mother y's favorite color.
Context: Billy's mother can be very embarrassing sometimes. When she has his friends over to play, she asks them all sorts of personal questions, which they are usually reluctant to answer. Yesterday, she asked them what their favorite color is, but only Billy answered.

Critically, on the two mixed readings, the two pronouns are co-located but receive different interpretations. The strong loci-as-variables hypothesis thus undergenerates.

On the other hand, the latter example in fact shows an interesting parallel with phi-features in spoken language. Specifically, phi-features may be 'uninterpreted' when bound by focus-sensitive operators like *only*. For example, the bound reading of (25) entails that no other

[3]There is a small quirk to this pattern, commonly known as Dahl's puzzle: when one pronoun c-commands the other, one of the two mixed readings becomes unavailable (Dahl 1974).

individuals in some comparison set did their homework. What is interesting is that this comparison set is not restricted to individuals that match the phi-features of the pronoun; for example, it can include John, who is not female.

(25) Only Mary did her$_{[+\text{fem}]}$ homework.
Entails: *John didn't do his homework.*

This pattern extends to ASL loci: when a pronoun is bound under ONLY-ONE (as in several readings of (23)), its interpretation in the comparison set may range over individuals who are indexed at other loci, such as Jessica in (23), indexed at locus a.

Thus, the strong loci-as-variables hypothesis has been falsified. In contrast, loci share important formal properties with morphosyntactic features.

At this point, there are essentially two directions that a theory can go. The first route is the more radical: since ASL loci do not necessitate a variable-based analysis, Kuhn 2015a provides a purely feature-based analysis in a variable-free, Directly Compositional framework. Alternatively, weaker forms of the variable-based hypothesis are available. Schlenker (to appear), recognizing the problems presented here, presents one such weakening: an analysis in terms of 'featural variables,' where variables, like features, may also be subject to erasure. We leave the choice between these directions open.

3.2 Spatial syncretisms

Within feature-based analyses of loci, two explicit accounts have recently been proposed: Steinbach and Onea 2015 and Kuhn 2015a. These two analyses target slightly different empirical domains, so differ accordingly in framework: the former (in Discourse Representation Theory) is designed to account for dynamic binding across sentences, so is not compositional; the later (in Combinatory Categorial Grammar) is designed for account for quantificational binding within sentences, so is not dynamic. Nevertheless, the two accounts share a number of formal properties, which make similar predictions regarding cases of *underspecification* of locus features. Kuhn 2015a observes that these patterns parallel behavior of features that has been documented for spoken language.

Steinbach and Onea 2015 and Kuhn 2015a observe that nouns, pronouns, and verbs may be underspecified for locus. For example, while the form of an agreeing verb determines the loci of its arguments; non-agreeing verbs are underspecified in the sense that they are compatible with arguments at any locus. Similarly, a null pronoun inherently cannot display spatial features, so is underspecified in that it can be associated with an antecedent at any locus. In DGS, Steinbach and Onea claim that overt pronouns, too, can be underspecified for locus; in (26), the neutral pronoun can pick out either of two discourse referents.

(26) **DGS** (Steinbach and Onea 2015)
MARIA IX-a NEW TEACHER IX-b LIKE. IX-neutral SMART.
'Maria likes the new teacher. {Maria / The new teacher} is smart.'

Indeed, in DGS, Steinbach and Onea 2015 report that multiple levels of underspecification are possible: a pronoun that is directed generally to the right side of the signing space may pick out a discourse referent on the near right or the far right.

Kuhn 2015b observes that these patterns of underspecification are analogous to cases of *syncretisms* in spoken language, where two morphological forms of a word are phonologically identical. In English, for example, the nominative and accusative forms of the second person pronoun display a syncretism (*you*/*you*, compared to *he*/*him*). In German, the noun *Frauen*, 'woman' is identical in the accusative and dative case, meaning that it can serve as an argument both for verbs that select accusative case (e.g. *findet*, 'find') and for those that select dative case (e.g. *hilft*, 'help'). From this point of view, neutral pronouns in DGS (and perhaps ASL) display a syncretism, able to retrieve an antecedent at any locus.

Johnson and Bayer 1995 observe that theories of syncretisms make specific predictions regarding the coordination of unlike categories: namely, when constituents of two different categories are coordinated, the resulting constituent can only combine in the grammar with an argument that shows a syncretism with respect to the same categories. This prediction can be made concrete with a German example. When a verb that subcategorizes for an accusative object is coordinated with a verb that subcategorizes for a dative object, the resulting complex verb can only take arguments that are syncretic between accusative and dative case. The prediction is borne out: *Frauen* is grammatical in such cases; *Männer/Männern*, 'man-ACC/DAT' is not.

(27) **German** (Johnson and Bayer 1995)

a. * Er findet und hilft Männer.

b. * Er findet und hilft Männern.

c. Er findet und hilft Frauen.
'He finds and helps women.'

In sign language, the frameworks used by Kuhn 2015a and Steinbach and Onea 2015 make an analogous prediction: when you coordinate a DP at locus a with a DP at locus b, the resulting complex DP can only bind pronouns that are syncretic between locus a and locus b. As it turns out, data of precisely this nature is discussed by Schlenker 2011, in the form of disjunctive antecedents. Specifically, when two DPs at distinct loci are coordinated with OR, the resulting discourse referent can be retrieved by a (syncretic) null pronoun, but not by an overt pronoun that is itself specified for locus.

(28) **ASL** (Schlenker 2011)

a. BLACK-m OR ASIA-m WILL WIN NEXT PRES. ELECTION. ∅ WILL WIN AHEAD.

b. BLACK-a OR ASIA-b WILL WIN NEXT PRES. ELECTION. ∅ WILL WIN AHEAD.

(29) a. BLACK-m OR ASIA-m WILL WIN NEXT PRESIDENT ELECTION. IX-m WILL WIN AHEAD.

b. ?? BLACK-a OR ASIA-b WILL WIN NEXT PRESIDENT ELECTION. IX-{a/b} WILL WIN AHEAD.

'An African-American or an Asian-American will win the next presidential election. He will win by a large margin.'

More empirical work is needed to evaluate the extent of this parallel. We also note that alternative explanations may be possible for the sign language data (see, e.g., Schlenker 2011's variable-based analysis of the paradigm above). Nevertheless, given the freedom with which loci can be assigned, the directions discussed here provide a potentially very rich domain with which to investigate theories of underspecification and syncretisms that have been built based on spoken language.

3.3 Pictorial loci

Another theoretical tension introduced by sign language regards the interaction of the combinatorial grammar with iconic, pictorial representations.

As emphasized in §2, the patterns that we see in sign language (in pronouns as elsewhere in the grammar) fit closely with discrete and categorial patterns familiar from spoken language. But sign language is also well known for its ability to express meaning in a demonstrative, picture-like way. For example, a zig-zagging motion of a hand can describe the zig-zagging motion of a vehicle, and a small circle with the fingers can describe a disk of the same size (see work on 'classifier' constructions, as in Emmorey 2003 (ed.)). Work by Cuxac 1999 and Liddell 2003, emphasize that these patterns have a systematicity to them, yet cannot be analyzed with the standard tools for language.

Schlenker, Lamberton and Santoro 2013 address this tension in the domain of pronouns. Looking at the geometric properties of singular and plural pronouns in ASL and LSF, they confirm that the form-to-meaning mapping contains an iconic component. However, they show that this can be reconciled without a hitch with the formal grammar: the iconic mapping defines a predicate—a set of objects—that then interacts in the grammar like as normal. Zucchi et al. (2012) and Davidson (to appear) reach a similar conclusion for the case of classifier constructions (i.e. category-specific pronominal forms that iconically express orientation and movement), showing that they can be captured by allowing a verb to take a 'demonstration' as an argument—that is, a set of pictorially described events.

This can be illustrated in somewhat more detail with the specific case of locus height. For ASL and LSF, Schlenker et al. 2013 establish that the height of a locus can be used to indicate the height of the value of the pronoun. For example, high loci are used for tall individuals, low loci are used for short individuals. Yet, this is not simply a matter of a $[\pm\text{tall}]$ feature on a pronoun: Schlenker et al. show that the height of the pronoun is also sensitive to whatever the orientation of referent happens to be. For example, the locus height for the same individual standing up, lying down, or hanging from a branch is different, depending on where the upper half of their body is located.

At the same time, however, these pronouns still obey the formal patterns described in §2; for example, Schlenker et al. 2013 demonstrate that pronouns with iconic height inferences still show sensitivity to binding conditions. The empirical situation thus calls for a way to

incorporate iconicity and formal grammar into a single system. Schlenker et al. thus define a rough iconic mapping inspired by geometric projection (see Greenberg 2013, for a more precise formulation), which returns the set of all individuals whose torso is in the indicated position, relative to some viewpoint. Based on the projective properties of these iconic meanings, Schlenker et al. incorporate this iconically defined predicate as a presupposition on the denotation of the pronoun. The pictorial information is thus 'packaged' in a way that allows it to passed along through the system as usual.

Of relevance to the discussion in §3.1, Schlenker 2014 further observes that these height/orientation inferences in some respects behave analogously to grammatical phi-features in spoken language. In particular, like gender features, person features, and (as seen above) choice of locus, Schlenker 2014 shows that height/orientation inferences are left uninterpreted under ellipsis and focus sensitive operators. Schlenker ultimately rules that the LSF judgments are not clear enough to definitively dissociate these effects from the behavior of not-at-issue (e.g. presupposed) material in general (as opposed to specifically the behavior of features). Nevertheless, a unified picture begins to emerge where loci—both in their iconic and their grammatical uses—are incorporated as a presupposed or featural component on a pronoun.

4 Dynamic semantics

4.1 Background on dynamic semantics

Perhaps one of the largest theoretical shifts in semantic theory has been the shift from traditional, static semantics to theories of dynamic semantics. On traditional, static views of meaning, sentences denote sets of worlds or situations: essentially, those in which the sentence is true. Sentences in discourse are interpreted conjunctively, and restrict the set of worlds that are under discussion.

(30) a. It is raining. Richard laughed.
b. $\textbf{raining} \wedge \textbf{laughed}(\textbf{richard})$

However, a static conception of meaning faces challenges in light of more complex cross-sentential relations, such as discourse anaphora. The puzzle can be illustrated with the sentences in (31); here, the pronoun in the second sentence is most easily interpreted as referring to *whichever man entered*. Intuitively, we need to provide a meaning like the one in (32a), where the existential is able to scope over both sentences. The situation gets even more hairy with pronouns that occur several sentences away from their antecedent; somehow, the existential must be given *unbounded scope*. This is at odds with a standard static semantic theory, which locks in quantifier scope at a sentential level, with a logical form that generates the meaning in (32b). Note that on this meaning, there is no logical connection between the bound variable and the free variable.

(31) Someone entered. He laughed.

(32) a. $\exists x[\textbf{entered}(x) \wedge \textbf{laughed}(x)]$

b. $\exists x[\textbf{entered}(x)] \wedge \textbf{laughed}(x)$
$= \exists x[\textbf{entered}(x)] \wedge \textbf{laughed}(y)$

Dynamic semantics (Groenendijk and Stokhof 1991, Dekker 1993, Muskens 1996, among others) reconceptualizes the meaning of a sentence as a 'context-change potential,' that is, a function which changes the context in some way. The output context of one sentence becomes the input context for the following sentence. This yields a more powerful semantic system, allowing sentences to do more than just restricting what worlds we are talking about; in addition, it becomes possible for a sentence to add new discourse referents into a context. Specifically, a sentence is evaluated with respect to an assignment function—essentially, a list of all the individuals in the discourse context. Indefinites and proper names (e.g. *a man*, *John*) are interpreted *dynamically*: their semantic contribution is to add a new value to the list. The updated list serves as the input for the next sentence in the discourse.

The discourse in (33) illustrates how this allows the set of discourse referents to increase. We will assume a neutral context; this is represented by the starting state of a singleton set containing an empty list. Sentence (33a) contains the indefinite *a woman*, which assigns a value to one variable in the assignment function; the rest of the content of the sentence restricts what the value of this variable can be. The output of (33a) is the set of all assignment functions in which the first variable is assigned to some woman who entered. The following sentence has no dynamic elements in it; thus, the sentence itself is static, and the only contribution is to again restrict the possible values of the variable already assigned; the output of (33b) is thus a subset of the input of (33b). Finally, (33c) includes a proper name, which again introduces a variable whose value is restricted to the named individual; the other content in the sentence again adds restrictions to the possible values of the two variables.

(33) $\{ \boxed{}\boxed{}\boxed{} \cdots \}$

a. A woman walked into the office.
$\{ \boxed{x}\boxed{}\boxed{} \cdots \mid \textbf{woman}(x) \wedge \textbf{enter}(x)\}$

b. She was worried.
$\{ \boxed{x}\boxed{}\boxed{} \cdots \mid \textbf{woman}(x) \wedge \textbf{enter}(x) \wedge \textbf{worried}(x)\}$

c. She was looking for Ed.
$\{ \boxed{x}\boxed{y}\boxed{} \cdots \mid \textbf{woman}(x) \wedge \textbf{enter}(x) \wedge \textbf{worried}(x) \wedge y = \textbf{ed} \wedge \textbf{search}(y)(x)\}$

On a dynamic view, the meaning of a dynamically-bound pronoun is the same as the meaning of a pronoun that is quantificationally bound within a sentence. For example, in Groenendijk and Stokhof's Dynamic Predicate Logic, the meaning of a pronoun (in both cases) is the value of a variable; dynamic binding occurs when the value of this variable has been assigned in the context in which the pronoun is evaluated. (See below for variable-free treatments of dynamic semantics.) Note that the fact that each sentence is evaluated in the context of the previous sentence means that pronouns in a given sentence can only refer to the individuals that have been introduced by previous sentences.

One particularly influential case for the empirical domain encompassed by dynamic semantics is that of so-called 'donkey sentences,' as exemplified in (34).

(34) If a farmer beats a donkey, it kicks him back.

On standard assumptions, the indefinites in (34) are not in a position where they can syntactically bind their pronouns (though, see Barker and Shan 2008 for an alternative); thus, the pronouns in (34) must receive their interpretation through the same general mechanism that gives pronouns their interpretation in cross-sentential cases like (31). But in a conditional sentence like (34), co-variation in the donkey-farmer pairs is visible in the truth conditions of the sentence; the dynamic interpretation of the conditional must therefore allow quantification over assignment functions.

A few additional notes are relevant to mention:

Dynamic semantics has its roots in Discourse Representation Theory (DRT: Kamp 1981) and File Change Semantics (Heim 1982). In what follows, I will lump all these frameworks together under the heading 'dynamic semantics,' although, for somewhat subtle reasons, the DRT of Kamp 1981 is technically not dynamic. The reason for this is because DRT fundamentally includes an intermediate level of representation: the level of the Discourse Representation Structure (DRS). In DRT, words themselves are not given meanings; instead, words provide instructions to modify a DRS. It is then the completed DRS that is interpreted to give a truth conditional meaning. (So, for example, in Kamp's DRT, it would not be well-defined to, say, put semantic interpretation boxes around a sub-sentential constituent like $[\![\text{a dog}]\!]$.) The result of this intermediate stage is that the operations that correspond to context-change potential in dynamic theories are carried out in DRT at the stage of building a DRS, as opposed to the stage of interpretation. Nevertheless, the underlying dynamic connection between DRT and dynamic semantics is brought out by Muskens 1996, who provides a compositional formulation of DRT where sub-sentential constituents are directly interpreted; the resulting system is dynamic in the same sense as other dynamic systems.

A final important fact is that the insights of dynamic semantics are perfectly compatible with variable-free theories of semantics, a point made by Szabolcsi 2003. In particular, although variable names provide a convenient way to refer to the slots in the lists that are dynamically passed through the composition of discourse, these are not fundamental to the dynamic architecture. Szabolcsi 2003 provides a semantics that is variable-free, yet represents sentences as context-change potentials and analyzes cross-sentential anaphora via binding, as in dynamic semantics. This fact will be relevant to the interpretation of Schlenker 2011's loci-based arguments in favor of dynamic semantics in light of Kuhn 2015a's arguments against a variable-based view of loci.

4.2 E-type theories of cross-sentential anaphora

What cross-sentential binding and donkey sentences show is that some enrichment to the semantics is needed to allow a pronoun to covary with an indefinite that is not in a position to

scope over it, but the precise nature of this enrichment has been a matter of debate. Under dynamic theories, as we have seen, words and sentences are able to introduce individual variables into the context that get passed along through the discourse. All pronouns, whether locally or dynamically bound, are individual-type variables.

In E-type theories of anaphora (Evans 1980, Elbourne 2005), the semantics is enriched not by assignment functions that pass individual variables through the discourse, but by situations—minimal information states with information about the world. For example, the first sentence in (31) would denote the set of minimal situations in which a single man entered. Under E-type theories, cross-sentential pronouns and donkey pronouns are not variables, instead, they are analyzed as definite descriptions, so the Logical Form of *he* in the second sentence of (31) is the definite description *the man*. Critically, the value of this definite description must come from some formal link to the previous discourse; Elbourne 2005 takes this to be a case of syntactic ellipsis: a pronoun is a definite description with an ellipted NP retrieved from a syntactic antecedent.

The detailed range of phenomena in spoken language has caused the E-type analysis to converge with the dynamic analysis in many respects. For example, as for dynamic semantics, donkey sentences again necessitate quantification—in this case, over situations. In fact, Dekker 2004 argues that when the E-type analysis becomes sufficiently fine-grained to deal with the range of data, it may even become isomorphic to dynamic semantics. The critical examples are cases of donkey sentences that contain two completely symmetric indefinites, as in (35).

(35) When a bishop meets a bishop, he blesses him.

What is important here is that the minimal situation described by the antecedent does not introduce a unique individual that can be retrieved by the pronoun. '*The bishop*' is not well defined, because there are two of them; indeed, even the longer definite description '*the bishop that meets a bishop*' is not well defined, as the verb describes a symmetric relation.

Elbourne 2005's answer to this puzzle is to posit that *meet* is in fact *not* a symmetric relation as far as situations are concerned: the situation in which A meets B is distinct from the situation in which B meets A. Dekker 2004 claims that retrieving individuals from such fine-grained situations becomes isomorphic to retrieving the values of variables from an assignment function, thus converging with dynamic semantics.

4.3 Sign language contributions

Schlenker 2011 argues that sign languages (specifically, ASL and LSF) provide the final straw of evidence in favor of dynamic theories, to the extent that the two theories are not notational variants.

As discussed above, empirical data has forced the E-type theory to essentially replicate formal aspects of a dynamic theory, to the point where the E-type theory threatens to become a notational variant of a dynamic system (Dekker 2004). Schlenker, however, observes that one critical difference still distinguishes the two theories: namely, the formal link between a

pronoun and its antecedent. In dynamic semantics, this link arises semantically, via binding (on a variable-based system, through the co-indexation of a pronoun with its antecedent); on an E-type theory, the link arises syntactically, via NP ellipsis.

Schlenker observes that in sign language, this link is made overt; as we have seen, a pronoun must point towards the locus of its antecedent. The question then is: when you point to a pronoun in cases of cross-sentential anaphora or donkey anaphora, are you retrieving a semantic variable, or are you retrieving syntactic material?

As discussed in §3, one unique feature about loci is the arbitrary connection between an NP and its locus, so different occurrences the same NP (e.g. BISHOP) can be indexed at two different loci. Schlenker makes use of this arbitrarity to dissociate the syntactic material (the NP) from the semantic denotation (the variable, essentially). Specifically, if there are two identical NPs in a sentence (as in the *bishop*-sentences above), these NPs can nevertheless be placed at two distinct loci. One such example from Schlenker 2011 is given in (36).

(36) **ASL** (Schlenker 2011)
WHEN SOMEONE$_a$ AND SOMEONE$_b$ LIVE TOGETHER, …

a. IX-a LOVE IX-b.
b. IX-b LOVE IX-a.
c. # IX-a LOVE IX-a.
d. # IX-b LOVE IX-b.

'When someone and someone live together, one loves the other.'

Recall that the link between a pronoun and its antecedent on an E-type theory is a matter of syntactic ellipsis. In an E-type theory for sign language, then, the only contribution of pointing to a locus is to identify the NP material that should be retrieved for the definite description. Counterintuitively, this predicts that pointing to the locus where one individual was indexed can retrieve an individual who was indexed at a different locus *as long as the two were described symmetrically*. An equally counterintuitive corollary is the prediction that pointing to the first locus twice in these cases should not result in a Condition A violation, since the semantics is able to provide an interpretation where the two pronouns receive different meanings.

The example in (36) shows that this prediction is *not* borne out, since the sentences in (36c) and (36d) are ungrammatical, showing the existence of a Condition A violation. The E-type theory is thus falsified.

One of the things that this debate brings out is the idea that semantic objects which intuitively feel quite different—situations vs. assignment functions—can nevertheless have very similar formal properties. As both situation/event semantics and dynamic semantics are enriched to encompass to new empirical domains (such as plurals), I think it's an open question whether these formalisms will ultimately be isomorphic, or whether they can be teased apart.

4.4 Dynamic semantics of plurals

In the last 20 years, the framework of dynamic semantics has been enriched to allow the semantic system to represent and manipulate functional relationships between plural discourse referents (van den Berg 1996, Nouwen 2003, Brasoveanu 2012). Motivating examples include sentences like (37), where the final pronoun retrieves a functional antecedent that is constructed by the interaction of the distributive operator and the indefinite in the preceding sentence.

(37) Three boys each saw a girl. They each waved to her.

Notably, the interpretation of the final pronoun depends on a correspondence that was introduced by the first sentence. The sentences entail that *whichever* girl was seen by each boy, *that* is the girl that he waved to. In order to represent this meaning, the semantic system must represent not only lists of individuals, but *sets* of lists of individuals. Adapting the conventions used earlier, evaluating the two sentences in (37) would thus yield the output state shown in (38).

(38) $\{$ $\begin{array}{|c|c|c|}\hline x_1 & y_1 & \\ \hline x_2 & y_2 & \\ \hline x_3 & y_3 & \\ \hline \end{array}$ $\cdots \ |\forall i, \textbf{boy}(x_i) \wedge \textbf{girl}(y_i) \wedge \textbf{saw}(y_i)(x_i) \wedge \textbf{waved}(y_i)(x_i)\}$

A growing body of recent work has shown that this kind of constructed, functional reference appears in a wide variety of phenomena beyond pronouns: Henderson 2014 discusses the role of functions in dependent indefinites (where an indefinite is inflected to indicate that it varies with respect to another argument); Bumford 2015 discusses the role of functions in the 'internal' readings of adjectives like *same* and *different*. Without getting into the details of these accounts, observe that the only way to state the truth conditions for the sentence in (39) is by making reference to the boy-book correspondences. This means that a paraphrase in terms of functions, as below, is very natural way to state the truth conditions.

(39) a. Every boy read the same books.
'The function from boys to the books they read is a constant function.'

Strikingly, what is conceptually unified within these theories has been shown to be *visibly* unified in sign language. Specifically, in ASL, Kuhn 2015b shows that dependent indefinites and the adjectives SAME and DIFFERENT in ASL all employ spatial co-location to specify dependency relations. For example, in (40), the indefinite ONE or the adjective SAME moves in an arc-movement over the same area of space that was established by the plural BOY. This inflection has a semantic effect: (40a) entails that a plurality of books are distributed over the boys, one each; (40b) only allows an 'internal' reading where the 'sameness' is distributed over the boys. Kimmelman 2014 presents analogous data for RSL, looking at distributive marking on numerals, nouns, and verbs.

(40) **ASL** (Kuhn 2015b)

a. BOYS IX-arc-a READ ONE-arc-a BOOK.
'The boys read one book *each*.'

b. ALL-a BOY READ SAME-arc-a BOOK.
'All the boys read the same book *as each other*.'

Notably, through the use of spatial agreement, sign language is able to disambiguate readings where spoken language cannot. In particular, dependent indefinites in spoken language (e.g. in Hungarian) are ambiguous when there are multiple potential licensors; in ASL, they are not.

(41) **Hungarian** (Kuhn 2015b)

A fiúk két-két könyvet adtak a lányoknak.
The boys two-two book give.3Pl the girls
'The boys gave the girls two books {per boy OR per girl}.'

(42) **ASL** (Kuhn 2015b)

ALL-a BOY GAVE ALL-b GIRL ONE-arc-b BOOK.
'All the boys gave all the girls one book *per girl*.'

These data show that the semantic representation of dependent indefinites in ASL must be rich enough to represent the connection between the dependent indefinite and its licensor. Kuhn 2015b argues that the recent dynamic treatments of plurals provide exactly the tools that are needed for this end.

5 Conclusion

In this chapter, I looked at the case study of pronominal reference in sign language. Grounded in the robust finding that sign language pronouns and spoken language pronouns are part of the same system, we turned to a series of semantic debates where the unique properties of sign language offered to yield new insights.

First, we examined the degree to which loci reflect the properties of formal variables. There are a number of compelling parallels—e.g., the unbounded number of them and the arbitrary choice of locus—but we observed other respects in which the constraints of variables are too strict to generate the patterns of ASL. This led us to a feature-based view of loci. Examining cases of underspecification, we saw one area in which this featural analysis may be leveraged to give new insights. Turning to cases of iconicity, we reviewed analyses that successfully incorporated iconic meaning into a combinatorial grammar. When iconic meaning appeared on pronouns, we saw that it exhibited several of the properties of grammatical features, thus dovetailing with the results on non-iconic uses of loci.

We then turned to cross-sentential cases of anaphora, where dynamic semantics was pitted against an E-type, situation-semantics view. We showed that the sign language data provides evidence that a theory like dynamic semantics is necessary in order to capture the full range of data. Finally, looking at a wide range of examples involving distributive marking, we argued

that sign language provides support for recent enrichments of dynamic semantics in which the semantic system represents functional relationships between plural discourse referents.

References

Aronoff, M., Meir, I., and Sandler, W. (2005). The paradox of sign language morphology. *Language*, 81(2):301–334.

Brasoveanu, A. (2012). Modified numerals as post-suppositions. *Journal of Semantics*, 30(2):155–209.

Bumford, D. (2015). Incremental quantification and the dynamics of pair-list phenomena. *Semantics and Pragmatics*, 8(9):1–70.

Cecchetto, C., Cecchetto, A., Geraci, C., Santoro, M., and Zucchi, S. (2015). The syntax of predicate ellipsis in Italian Sign Language (LIS). *Lingua*.

Curry, H. B. and Feys, R. (1958). *Combinatory Logic*. Holland Publishing Co., Amsterdam, Netherlands.

Cuxac, C. (2001). French sign language: Proposition of a structural explanation by iconicity. In Braffort, A., Gherbi, R., Gibet, S., Teil, D., and Richardson, J., editors, *Gesture-based communication in human–computer interaction*, Lecture Notes in Computer Science, pages 165–184. Springer Berlin Heidelberg.

Dahl, O. (1974). How to open a sentence: Abstraction in natural language. Logic Grammar Reports 12, University of Goteborg, Goteborg, Sweden.

Davidson, K. (to appear). Quotation, demonstration, and iconicity. *Linguistics and Philosophy*.

Dekker, P. (1993). *Transsentential meditations: ups and downs in dynamic semantics*. PhD thesis, University of Amsterdam.

Dekker, P. (2004). Cases, adverbs, situations and events. In Kamp, H. and Partee, B., editors, *Context-dependence in the analysis of linguistic meaning*. Elsevier, Amsterdam, Netherlands.

Elbourne, P. (2005). *Situations and Individuals*. Current Studies in Linguistics. MIT Press, Boston, MA.

Emmorey, K., editor (2003). *Perspectives on classifier constructions in signed languages*. Lawrence Erlbaum Associates, Mahwah, NJ.

Evans, G. (1980). Pronouns. *Linguistic Inquiry*, 11(2):337–362.

Geraci, C. (2014). Spatial syntax in your hands. In Iyer, J. and Kusmer, L., editors, *Proceedings of the 44th Meeting of the North East Linguistic Society (NELS)*, pages 123–134.

Giorgolo, G. (2010). *Space and Time in Our Hands*. PhD thesis, Utrecht University.

Graf, T. and Abner, N. (2012). Is syntactic binding rational? In *Proceedings of the 11th International Workshop on Tree Adjoining Grammars and Related Formalisms*, pages 189–197, Paris, France.

Greenberg, G. (2013). Beyond resemblance. *Philosophical Review*, 122(2):215–287.

Groenendijk, J. and Stokhof, M. (1991). Dynamic predicate logic. *Linguistics and Philosophy*, 14(1):39–100.

Heim, I. (1982). *The Semantics of Definite and Indefinite Noun Phrases*. PhD thesis, University of Massachusetts, Amherst, MA.

Henderson, R. (2014). Dependent indefinites and their post-suppositions. *Semantics and Pragmatics*, 7(6):1–58.

Jacobson, P. (1999). Towards a variable free semantics. *Linguistics and Philosophy*, 22(2):117–184.

Johnson, M. and Bayer, S. (1995). Features and agreement in lambek categorial grammar. *Proceedings of the Formal Grammar Workshop*, pages 123–137.

Kamp, H. (1981). A theory of truth and semantic representation. In Groenendijk, J., Janssen, T., and Stokhof, M., editors, *Formal Methods in the Study of Language*, volume 135 of *Mathematical Center Tracts*, pages 277–322. Amsterdam, Netherlands.

Kimmelman, V. (2015). Distributive quantification in russian sign language. In *Formal and Experimental Advances in Sign Language Theory*, Barcelona, Spain.

Koulidobrova, E. (2009). SELF: Intensifier and 'long distance' effects in ASL. Paper presented at the *21st European Summer School in Logic, Language, and Information*.

Koulidobrova, H. (2012). *When the Quiet Surfaces: 'Transfer' of Argument Omission in the Speech of ASL-English Bilinguals*. PhD thesis, University of Connecticut.

Koulidobrova, H. and Lillo-Martin, D. (to appear). A 'point' of inquiry: The case of the (non-) pronominal IX in ASL. In Grosz, P. and Patel-Grosz, P., editors, *Impact of Pronominal Form on Interpretation*, Studies in Generative Grammar. Mouton de Gruyter.

Kuhn, J. (2015a). ASL Loci: Variables or Features? *Journal of Semantics*.

Kuhn, J. (2015b). *Cross-categorial singular and plural reference in sign language*. PhD thesis, New York University.

Liddell, S. (2003). *Grammar, gesture, and meaning in American Sign Language*. Cambridge University Press, Cambridge, UK.

Lillo-Martin, D. (1986). Two kinds of null arguments in American Sign Language. *Natural Language and Linguistic Theory*, 4:415–444.

Lillo-Martin, D. (1991). *Universal grammar and American Sign Language*. Studies in Theoretical Psycholinguistis. Springer Netherlands.

Lillo-Martin, D. and Klima, E. (1990). Pointing out differences: ASL pronouns in syntactic theory. *Theoretical Issues in Sign Language Research*, 1:191–210.

Lillo-Martin, D. and Meier, R. (2011). On the linguistic status of 'agreement' in sign languages. *Theoretical Linguistics*, 37(3/4):95–141.

Muskens, R. (1996). Combining Montague semantics and discourse representation. *Linguistics and Philosophy*, 19(2):143–186.

Neidle, C., Kegl, J., MacLaughlin, D., Bahan, B., and Lee, R. G. (2000). *The Syntax of American Sign Language: Functional Categories and Hierarchical Structure*. MIT Press, Cambridge, MA.

Nouwen, R. (2003). *Plural pronominal anaphora in context: Dynamic aspects of quantification*. PhD thesis, Utrecht University, Utrecht, Netherlands.

Perniss, P. and Zeshan, U. (2008). Possessive and existential constructions in Kata Kolok. In Zeshan, U. and Perniss, P., editors, *Possessive and existential constructions in sign languages*, number 2 in Sign Language Typology, chapter 6, pages 125–150. Ishara Press.

Quine, W. (1960). Variables explained away. *Proceedings of the American Philosophical Society*, 104(3):343–347.

Santoro, M. and Geraci, C. (2013). Weak crossover in LIS. In *Theoretical Issues in Sign Language Research*, London, UK. University College London.

Schlenker, P. (2011). Donkey Anaphora: the View from Sign Language (ASL and LSF). *Linguistics and Philosophy*, 34(4):341–395.

Schlenker, P. (2014). Iconic features. *Natural Language Semantics*, 22(4):299–356.

Schlenker, P. (to appear). Featural variables. *Natural Language and Linguistic Theory*. Available at http://ling.auf.net/lingbuzz/002128.

Schlenker, P., Lamberton, J., and Santoro, M. (2013). Iconic variables. *Linguistics and Philosophy*, 36(2):91–149.

Schlenker, P. and Mathur, G. (2013). A strong crossover effect in ASL. *Snippets*, 27:16–18.

Sharvit, Y. (1999). Resumptive pronouns in relative clauses. *Natural Language and Linguistic Theory*, 17(3):587–612.

Steinbach, M. and Onea, E. (2015). A DRT analysis of discourse referents and anaphora resolution in sign language. *Journal of Semantics*.

Szabolcsi, A. (1987). Bound variables in syntax: Are there any? In Groenendijk, J., Veltman, F., and Stokhof, M., editors, *Proceedings of the 6th Amsterdam Colloquium*, pages 331–353. ITLI, University of Amsterdam.

Szabolcsi, A. (2003). Binding on the fly: Cross-sentential anaphora in variable-free semantics. In Kruijff, G.-J. M. and Oehrle, R. T., editors, *Resource-Sensitivity, Binding and Anaphora*, pages 215–227. Kluwer Academic Publishers, Dordrecht, Netherlands.

van den Berg, M. (1996). *Some aspects of the internal structure of discourse: the dynamics of nominal anaphora*. PhD thesis, ILLC, Universiteit van Amsterdam.

Zucchi, S., Cecchetto, C., and Geraci, C. (2012). Event descriptions and classifier predicates in sign languages. In *Formal and Experimental Advances in Sign Language Theory*, Venice, Italy.