Cross-categorial singular and plural reference in sign language

by

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A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Department of Linguistics
New York University
September, 2015

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Philippe Schlenker

Acknowledgements

This dissertation would not have been possible without the input and support from a great many people. Some are listed here.

Thanks foremost to my committee. Philippe Schlenker has been an incredibly supportive advisor on many fronts, providing me great resources and freedom to explore natural language semantics, challenging and encouraging me in equal measure. Chris Barker, who I met with regularly throughout my five years at NYU, never let me lose sight of the big picture. Without Lucas Champollion, this dissertation would be entitled "Cross-categorial singular reference in sign language." Diane Lillo-Martin contributes an incredible wealth of knowledge on sign language linguistics to any conversation. Kathryn Davidson has been a productive and dynamic interlocutor and sets a high standard for sign language semanticists.

It has been an honor and privilege to become involved with the Deaf community in New York and in Paris. I would like to extend a particularly large thank you to Jonathan Lamberton, who has been incredibly helpful, insightful, and patient with me over the course of several years of working together. A Paris, je voudrais remercier en particulier Thomas Levêque, comme collègue et ami.

Several individuals merit special thanks for their contribution to specific chapters. My understanding of the formal systems developed in Chapter 4 is thanks in large part to discussions with Dylan Bumford. Chapter 6 would not have been written if not for stimulating discussion with Tricia Irwin, beginning with a 21 message long e-mail thread appearing inaccurately under the subject line "two quick questions." Chapter 7 is coauthored with Valentina Aristodemo, as indicated at the beginning of the chapter.

Other individuals have had a great impact on both my dissertation and my time at NYU. From my first days of graduate school, I have had productive and educational conversations with Anna Szabolcsi. Working with Maria Gouskova taught me how to write academic papers efficiently and effectively. Spending time in Paris gave me the opportunity to benefit from interaction with yet more excellent researchers, notably Carlo Geraci, Emmanuel Chemla, and Benjamin Spector. I would not be a linguist if it were not for Pauline Jacobson, who continues to inspire me.

It is hard to overstate the amount that I have learned from my fellow classmates during my time in graduate school. Thanks to Valentina Aristodemo, Carina Bauman, Dylan Bumford, Simon Charlow, Tricia Irwin, Itamar Kastner, Sonia Kasyanenko, Nathan LaFave, Tim Leffel, Tal Linzen, Sean Martin, Salvador Mascarenhas, Neil Myler, Mirko Santoro, Allison Shapp, Dániel Szeredi, Jérémy Zehr, and Vera Zu.

The frantic final weeks of writing a dissertation provide a particularly strong reminder that no work of this scale can be undertaken without an incredible amount of support from friends and family. In addition to all the people already mentioned, thanks to the jugglers, dancers, and other ne'er-do-wells who supported me through the process. Thanks to my parents.

H. W. Kuhn (2002), *Operations Research* 50(1), highlights the role of chance in scientific discovery—"being in the right place at the right time." For myself, being in New York over the past five years has been lucky not only from a scientific perspective but also because it gave me five years to regularly spend time with my New York family. Thanks to Jon and Michele, Alice and John, and Grandma and Grandpa.

Abstract

This dissertation addresses a range of semantic topics—anaphora, plurality, dependency, telicity, and pluractionality—and investigates them from the point of view of sign language, focusing on data from American Sign Language and French Sign Language. The importance of sign language to these debates arises from its visuospatial modality, in which the hands and face generate a signal that is perceived with the visual system. From a semantic perspective, this modality offers several unique expressive possibilities, including the ability to use space in a meaningful way, and the pervasive availability of iconic, picture-like representations. In this dissertation, I argue that the use of space in sign language provides a new window into the machinery underlying the compositional system; I leverage the properties of the visuospatial modality to gain new insights into theories of natural language semantics.

Chapter 2 overviews several areas where sign language has previously been argued to bear on semantic debates, focusing in particular on the case of singular pronouns. The chapter reviews debates about variables, the role of iconicity, and cross-sentential anaphora. Of particular relevance to subsequent chapters, the chapter introduces theories of dynamic semantics, in which discourse referents can be introduced into a discourse context.

The last 20 years have seen enrichments to the theory of dynamic semantics, allowing the semantic system to represent and manipulate functional relationships between plural discourse referents. In Chapters 3 and 4, I argue that American Sign Language provides new evidence in favor of these new dynamic theories of plurals. In Chapter 3, I show that dependent indefinites and the adjectives SAME and DIFFERENT in ASL are strikingly unified through the use of space; dependency is overtly represented through spatial association. Chapter 4 provides a new analysis of dependent indefinites within the framework of Dynamic Plural Logic; I argue that the ASL data informs recent debates about dependency in spoken language.

In Part II of the dissertation, I turn to questions regarding iconicity. Like spoken languages, sign languages can communicate information through a discrete combinatorial system that combines words and morphemes into meaningful sentences. Additionally, though, sign languages are famous for displaying a 'pictorial' quality; they can communicate information graphically, through an iconic mapping that preserves information about the form of a sign. Thus, in the second part of the dissertation, I investigate the relation between iconicity and the combinatorial grammar, focusing on points of interface between the two, where iconic representations result in categorical effects that feed into the combinatorial system.

Chapter 6 addresses the existing observation that, in many sign languages, the telicity of a predicate is often reflected in the phonological form of the verb. I argue that this pattern arises from an iconic mapping that maps the phonetic form of a verb to the progression of the event it denotes. I present an analysis in terms of a scalar semantics for change-of-state verbs; phonetic endpoints iconically represent the maxima of closed scales, resulting in telic interpretations.

In Chapter 7, I address cases of verbal pluractionality in French Sign Language, in which repetition of a verb in one of several ways communicates that there are a plurality of events. This chapter brings together several themes from the preceding chapters: at the same time as displaying iconic effects similar to those discussed in Chapter 6, pluractional verbs in LSF show

licensing patterns that are formally identical to those from Chapters 3 and 4.

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Chapter 1

General Introduction

1.1 General overview

Much contemporary work in semantics—and especially in the framework of dynamic semantics—has investigated the ways that language is able to introduce, manipulate, and retrieve singular and plural discourse referents. I will address these topics from the point of view of sign language, focusing on American Sign Language and French Sign Language.

The value of sign language to this subject arises from its unique modality, in which the use of space plays an important semantic role, and in which iconicity is deeply and pervasively incorporated into the grammar. The result of this is that certain semantically-significant syntactic objects that have been postulated based on indirect evidence in spoken language are made phonologically overt in sign language in spatial or iconic ways. This fact allows old semantic debates to be revisited from new perspectives, and opens new questions that emerge only by virtue of considering the expressive potential offered by a visual modality.

Two general themes that form the core of this dissertation are plurality and iconicity.

1.1.1 Plurality

A wide variety of constructions in language have been shown to involve plurality at some level. These include not only plural nouns (e.g. *dogs*), but also semantically more complex words like *same*. Considering *same*, for example, the plurality involved is perhaps initially obscured (after all, if it's the same, then there's only one of it!), but some reflection reveals that *same* requires a set of at least two things to be compared. Thus, the 'plurality' of *same* arises by virtue of a relation to another plural in the sentence or in context. A diverse array of other constructions show similar patterns, where one word is reliant, or dependent, on association with another plural. These include dependent indefinites, certain patterns of pluractional verbs, and adjectives like *same* and *different*. Many of these domains have motivated new semantic frameworks, because their semantics pose challenges of compositionality for standard theories.

It turns out that ASL makes a very intuitive, morphological natural class out of all of these constructions. Semantic objects corresponding with nominal plurality are arranged in space in the horizontal plane in front of the signer. Semantic objects corresponding to verbal plurality (i.e. multiple events) involve a repeated motion. These morphological classes go beyond just (pro)nouns and verbs themselves; the markings appear also on modifiers like numerals (*one*, *two*, etc.) and adjectives like *same* and *different*.

In Chapters 3, 4, and 7 of this dissertation, I employ the unique properties of the sign language modality to address questions of composition that arise out of the domain of plurals. I argue that the patterns in American Sign Language provide evidence for certain recent theories of dynamic semantics, in which plurals and dependencies are represented and manipulated (Dynamic Plural Logic: van den Berg 1996, Nouwen 2003, Brasoveanu 2012).

1.1.2 Iconicity

In Part II of the dissertation ('Verbs'), iconicity takes center stage. A wide range of literature documents the fact that sign language has a 'pictorial' quality to it: it is able to communicate information not only by combining words and morphemes, but also by using space to communicate information graphically. To date, however, only a relatively small amount of work has begun to investigate the way that the iconic mode of representation interacts with the formal grammar (notable are Schlenker, Lamberton and Santoro 2013, and Davidson to appear). This work has also primarily focused on the nominal domain, which, describing concrete objects, has a fairly transparent mapping.

Thus, in the second part of this dissertation, I cast my eyes to iconicity in the verbal domain, where the iconic mapping becomes more abstract, representing the progression of events over time. I focus in particular on the points of *interface* between iconicity and the combinatorial grammar, where a gradient iconic system results in discrete, categorical effects in the linguistic system. Two specific points of interface include telicity (Chapter 6) and pluractionality (Chapter 7).

1.1.3 Outline

Chapter 2 sets the scene for following chapters by introducing various themes (e.g. iconicity; dynamic semantics) in perhaps their simplest form: singular pronouns. The chapter reviews previous results that both highlight the role of sign language in these debates, and also offer directions for extension. In Chapter 3, I move to cases of nominal plurality and nominal dependency, as described above. I sketch an informal analysis while drawing empirical parallels between a range of phenomena. Chapter 4 follows through on a promise of Chapter 3, and gives a formal fragment for one particular pattern—the case of dependent indefinites. The chapter presents and evaluates a number of fine-grained differences in formulations of Dynamic Plural Logic. Chapter 6 turns to the verbal domain—specifically, the observation by Wilbur (2003, 2008, 2009) that there is a correlation between the phonetic form of a verb and the telicity of its denotation. I argue that these results can be explained by the iconic representation of a scale associated with the verb. Finally, Chapter 7 (coauthored with Valentina Aristodemo) brings several of these threads together, investigating a pattern in French Sign Language where iconicity and plurality interact in the verbal domain.

1.2 Methodology

The arguments developed in this dissertation are based on empirical data from various sources, including novel field work in American Sign Language and French Sign Language as well as previously established patterns in both spoken and sign languages. (There are also a few new data points from spoken languages, indicated when relevant.)

American Sign Language judgments (Chapters 3, 6, and 7) are based on repeated judgments of one signer of ASL. French Sign Language judgments (Chapter 7) are based on repeated judgments with one signer of LSF. Both signers are Deaf native signers of their respective languages, children of Deaf, signing parents.

Data was gathered in the form of elicited judgments. ASL judgments were all gathered following the 'playback method' (Schlenker 2011). The signer was asked to sign a paradigm of sentences for a video recording. The resulting video was then played back for the same signer, who gave grammaticality judgments using a 7-point scale (with 7 best) and answers to any interpretation questions. Judgments could then be repeated on separate days. LSF judgments were elicited in a similar fashion, but with less regular use of the 7-point scale (in other cases, sentences were judged on the three point scale: ok, ?, *). Reports of all judgments were also video recorded.

Regarding the data in this dissertation, generally at least three judgments were elicited for sentences that exemplify new observations or are critical for the argument. Robustness was established both by retesting prerecorded videos and by testing novel sentences that replicated the pattern in a novel form (e.g. sentences with the same structure but different lexical items). Many paradigms also replicate or build on previously reported findings in the literature; these are discussed in the dissertation.

The appendix provides a full list of judgment tokens (on the 7-point scale when relevant). In the body of the dissertation, I collapse 7-point judgments into a binary distinction for ease of exposition. In general, the judgments for sentences discussed here showed a bimodal distribution, with sentences either receiving an average score of 6 or higher or an average score of 4 or less. I treat scores of greater than 4 as grammatical and mark scores of 4 or less with a '*' to indicate ungrammaticality. Intermediate judgments (with a mean between 4 and 6) are discussed in the body of the dissertation.

Some notes are relevant for specific chapters:

Many judgments in Chapters 6 and 7 are judgments of iconic forms. The nature of these forms makes binary or multiple-choice interpretation questions impossible, so first-pass interpretation questions were generally open ended (e.g. for an iconically inflected form of DIE 'what do you infer about the death?')

Chapter 7 discusses pluractionality and iconicity, focusing primarily on LSF, with some additional data from ASL. As is perhaps unsurprising, judgments from the two languages were essentially identical regarding iconic inferences, but diverged in a few ways with respect to grammaticalized aspects of the patterns. Thus, in the chapter, we draw conclusions about the iconic component based on the combined data from the two signers.

1.3 Notation

Following standard convention, signs in both ASL and LSF will be glossed with their closest English translation in all capitals. Personal pronouns, signed with a pointing index finger in both ASL and LSF, are glossed as IX (short for 'index'); possessive pronouns are glossed as POSS, and reflexive pronouns are glossed as SELF.

Lowercase letters a, b, and c in glosses are used to notate locations in the horizontal plane in front of the signer. (A location in space is called a 'locus,' plural form 'loci.') In any given sentence, alphabetical order of these letters indicates right-to-left placement of loci.

Inflectional marking will be written in lower-case letters after a sign; these inflections include the following:

- Inflection on pronouns, numerals, and adjectives:
  - arc : smooth movement of sign across horizontal plane
  - redup : reduplication of sign across horizontal plane
- Inflection on verbs:
  - rep : full repetition of sign
  - alt : two-handed alternating repetition of sign

For example, SAME-arc-a means that the sign for 'same' was moved in an arc-movement across an area of space at locus a. The meaning of these inflections will be described in the body of the dissertation.

Part I

Nouns

Chapter 2

Singular anaphora in sign language

2.1 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 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.

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 2.2 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 2.3 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 2.4, we turn to sign language contributions to debates about dynamic semantics.

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

2.2.1 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 boys x are such that x thought x would win?'

Similar results have been shown to hold for sign language. Lillo-Martin 1991 and Sandler & Lillo-Martin 2006 report crossover effects for ASL; Santoro & Geraci 2013 report similar facts for LIS. An example is given in (5).

(5) **ASL** (Lillo-Martin 1991)
$\overline{\text{STEVE}_a}^{T}$, IX-a EXPECT IX-1 LOVE ___.
Unavailable reading: 'Steve expects me to love him.'

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 ungrammaticality of (7b).

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

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

b. * $\overline{\text{[THAT COOKIE]}}^{\text{T}}{}_{a}$, IX-1 HOPE $_b$SISTER 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, cross-over effects, and resumptive effects.

2.2.2 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 2015 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 2015 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)
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 2015 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

[2] These examples also play an important role in the theory of dynamic semantics; we will return to these arguments in §2.4.

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$_{\text{a}}$, ALICE$_{\text{b}}$. 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$_{\text{a}}$ 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 2015 reports that analogous ambiguities exist for several signers of ASL. Schlenker 2014 reports similar results for both ASL and LSF.

(15) **ASL** (Kuhn 2015)
IX-a JOHN-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]$_a$ TELL-STORY IX$_a$ WANT WIN.
Intended: 'No politician said that he wanted to win.'

Kuhn 2015 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-ac/IX-neutral SMART.
'All the boys$_i$ think they$_{j/*i}$ are smart'
b. PETER THINK IX-a/IX-neutral SMART, JOHN$_b$ 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.

2.2.3 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 cross-over 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.

2.3 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. ≠ '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 §2.2, 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 2015, Steinbach and Onea 2015) posits that loci are a kind of syntactic feature—albeit one with the unusual properties described above.

Here, following Kuhn 2015, 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 2015, 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.

2.3.1 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 2015 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 2015)

In Kuhn 2015, I isolate 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.

In Kuhn 2015, I argue 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, I 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 2015)

EVERY-DAY, JOHN_a TELL MARY_a IX-a LOVE IX-a. BILL_b NEVER TELL SUZY_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. In Kuhn 2015, I report 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 2015)

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 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 $\text{her}_{[+\text{fem}]}$ 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.

[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).

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 2015 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 a variable resides as part of a morphosyntactic feature.

In the present work, I leave the decision between these choices fairly open, pursuing a variable-based analysis when this seems to offer the most insight. For instance, the use of variables will be particularly notable in my analysis of dependent indefinites in Chapter 4, where I explicitly assume variables to exist in the object language. The task of unifying these directions remains for future work.

2.3.2 ...or pictures?

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

As emphasized in §2.2, 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. 2011 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 [±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 §2.2; for example, Schlenker et al. 2011 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 §2.3.1, 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.

In this dissertation, I will build on these general questions, addressing what forms iconicity can take, and how it is incorporated into the grammar. Most investigations on iconicity to date have investigated the nominal domain, where iconic forms preserve information about size, location, and shape. In this dissertation (Chapters 6 and 7) I will extend this investigation to the verbal domain, where we see a more abstract iconic mapping: the motion of a phonetic form is mapped to the progression of an event. As with the literature discussed above, I will focus in particular on those places where these iconic mappings interact in interesting ways with the combinatorial grammar.

2.4 Dynamic semantics

2.4.1 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.

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

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 (27); 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 (28a), 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 (28b). Note that on this meaning, there is no logical connection between the bound variable and the free variable.

(27) Someone entered. He laughed.

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

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 (29) 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 (29a) 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 (29a) 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 (29b) is thus a subset of the input of (29b). Finally, (29c) 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.

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

b. She was worried.
$\{ \begin{array}{|c|c|c|}\hline x & \; & \; \\ \hline\end{array} \cdots \; |\mathbf{woman}(x) \wedge \mathbf{enter}(x) \wedge \mathbf{worried}(x)\}$

c. She was looking for Ed.
$\{ \begin{array}{|c|c|c|}\hline x & y & \; \\ \hline\end{array} \cdots \; |\mathbf{woman}(x) \wedge \mathbf{enter}(x) \wedge \mathbf{worried}(x) \wedge y = \mathbf{ed} \wedge \mathbf{search}(y)(x)\}$

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 (30).

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

On standard assumptions, the indefinites in (30) 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 (30) must receive their interpretation through the same general mechanism that gives pronouns their interpretation in cross-sentential cases like (27). But in a conditional sentence like (30), 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 ⟦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 2015's arguments against a variable-based view of loci.

2.4.2 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 (27) 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 (27) 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 (31).

(31) 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.

2.4.3 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 §2.3, 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 (32).

(32) **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 (32) shows that this prediction is *not* borne out, since the sentences in (32c) and (32d) are ungrammatical, showing the existence of a Condition A violation. The E-type theory is thus falsified.

In light of the discussion so far, the natural next question to ask is how the variables-or-features debate bears on the sign language argument in favor of dynamic semantics. That is, if loci are in fact features, as argued above—as opposed to variable names, as assumed by Schlenker 2011—does the argument still go through?

The situation is a bit subtle, but ultimately the answer is that it does, but it takes a slightly different form. The logic is as follows: if loci are features on a DP, then the E-type theory has two options: either the features are semantically interpreted, or they are not. If they are not interpreted, the two NPs are again identical, so Schlenker's pathology emerges as before. If they are interpreted, it is only to the end of arbitrarily distinguishing referents, thus closing the gap with dynamic semantics.

In the latter case, the E-type theory posits that the feature on the NP is interpreted in some way, thus breaking the semantic symmetry, allowing the E-type theory to proceed without problem. Schlenker 2011 provides evidence from French that suggests that a morphosyntactic asymmetry does have an effect for a similar pattern in French: the NP *homme*, 'man' is masculine, but the NP *personne de sexe masculin*, 'male person,' is feminine. Schlenker 2011 reports an improvement in the (33b), with pronouns of two morphosyntactic genders, over (33a), with only one.

(33) **French** (abridged from Schlenker 2011)

a. #? Quand un homme et un homme se rencontrent, il ne le salue pas.
When a man and a man SE meet, he NE him greet not
'When a man and a man meet, he doesn't greet him.'

b. ? Quand un homme et une personne de sexe masculin se rencontrent, il
When a man and a-fem person of gender masculine SE meet, he
ne la salue pas.
NE her greet not
'When a man and a male person meet, he doesn't greet him.'

In the case of French, however, the fact that gender is lexically specified allows a way out for an E-type theory, which can posit that 'man' and 'male person' are not in fact semantically identical.

As we have seen, though, sign language locus 'features' have the unique property of not being intrinsic to specific noun phrases (as we see in the ability to put SOMEONE$_a$ and SOMEONE$_b$ at distinct loci). Therefore, allowing E-type anaphora to be sensitive to this arbitrarily assigned property puts the ability to make arbitrary semantic distinctions into the syntax itself. The distinction between retrieving something from syntax and retrieving something from semantics is thus effectively collapsed, and the E-type theory converges with the dynamic theory.

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.

I do not address this question explicitly in this dissertation, but the reader may notice an echo of these issues in the formalisms that I choose at a couple of points in the dissertation. In particular, in Chapter 4, I define a plurality condition in terms of dynamic semantics, then in Chapter 7 I define a very similar looking plurality condition in terms of event semantics. My choice of formalism in each case is influenced by the specifics of the pattern in question (anaphoric dependencies in Chapter 4; event pluralities in Chapter 7), but I certainly do not dismiss the possibility that they could be united.

2.5 Looking forward

In this chapter, I looked at the case study of singular pronominal reference. 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. 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.

Finally, we turned to cross-sentential cases of anaphora, where dynamic semantics was pitted against an E-type, situation-semantics view. We argued that the sign language data, even under a feature-based view of loci, provides evidence that something like dynamic semantics is necessary in order to capture the full range of data.

In the coming chapters of my dissertation, I build on the topics that I have opened here, expanding in scope along a number of dimensions. In Chapters 3 and 4, I turn to recent theories where dynamic semantics is enriched to be able to deal with *plural* discourse referents and dependency relations. I will argue that sign language data provides general support in favor of these theories, but also allows us to tease apart differences between them. In Chapters 6 and 7, I turn to iconicity in the *verbal* domain, where it interacts with the formal grammar to yield categorical effects. Finally, Chapter 7 synthesizes several of these threads, bringing together both plurality and verbal iconicity.

Chapter 3

Functional reference in American Sign Language

3.1 Overview

A foundational question in formal semantics is the question: "What kinds of ontological objects can natural language make reference to?" Philosophers and semanticists have approached this question from a variety of perspectives, converging on a fairly unified answer: with pronouns, quantification, and various other means, there is an assortment of primitive objects that language can manipulate; these include at least individuals, times, and possible worlds (or perhaps events or situations). For example, in a sentence like 'no man is an island,' the truth-conditions require quantification over individuals; individuals can also be the value of a pronoun: *he*, *she*, or *it*. In a sentence like 'whenever it rains, it pours,' the truth-conditions require quantification over times or worlds; these objects also make up the values of pronouns like *then*.

Language can also manipulate and refer to higher-order objects, constructed from these semantic primitives. Perhaps the simplest example of a higher-order object is the case of plurals. Plurals are built up out of primitive objects—they are defined as sums of individuals (or, sums of events—see Chapter 7). Yet, plural objects also behave as an autonomous semantic unit: they can be picked out with the pronoun *they* and can be quantified over in certain constructions. For example, the sentence 'no two snowflakes are alike' requires quantification over pluralities (pairs) of snowflakes (for more on plural quantification, see discussion of 'covers' in Schwarzschild 1996).

In this chapter, I will focus on a particular higher-order object—the case of functions. Specifically, I am going to be looking at functional reference as it appears in American Sign Language. In general, I will argue that sign language provides a unique window into the question of reference, because it often represents objects overtly with the use of space. In particular, I will argue that the use of space provides new evidence in favor of recent theories of dependency in natural language in which functions can be built 'on the fly' through the logical correspondence of two plural arguments (e.g. Dynamic Plural Logic of van den Berg 1996, and related frameworks).

A large body of work on spoken language has shown that natural language is able to construct and manipulate functions. The motivating examples encompass a wide range of compositionally challenging phenomena; these include functional questions (Groenendijk and Stokhof 1984, Chierchia 1993), dependent indefinites (Brasoveanu and Farkas 2011, Henderson 2014), and 'internal' readings of adjectives like *same* and *different* (Brasoveanu 2011, Bumford 2015). Intuitively, what unifies these phenomena is the fact that one constituent in the sentence is *dependent* on another. Essentially, a function is a way of systematically relating one set of objects to another, of keeping track of correspondences.

This chapter presents the new finding that functional reference in ASL can be overtly realized. In ASL, plurals may be indicated in a variety of ways over areas of space. Here, I will show that two functionally associated plurals may be indexed over spatially associated areas of space. The result is that a range of disparate phenomena, all related to the abstract notion of functions, are overtly unified in a very intuitive phonological way in ASL.

Examples (34)–(36) provide a taste of the core data discussed in this chapter. In each sentence, the plural DP ALL BOY, 'all the boys,' is indexed over an area of space on the right-hand side of the signer (the locus a). Later in the sentence, the numeral or adjective moves in an arc movement over the same area of space. The resulting interpretation in each case is the same: the DP modified by the numeral or adjective must be dependent on the DP that introduced the locus.

(34) ALL-a BOY READ ONE-arc-a BOOK.
'All the boys read one book *each*.'

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

(36) ALL-a BOY READ DIFFERENT-arc-a BOOK.
'All the boys read different books *from each other*.'

In natural language, covert structure often results in ambiguity. As a result, if more structure is overt, there is less ambiguity. In ASL, since spatial association allows dependency to be overt, the empirical result will be to disambiguating sentences that are ambiguous in spoken language. Specifically, sign language will provide new insight into sentences where a dependent constituent has multiple possible licensors, a configuration that has been relevant to recent debates about the link between a dependent constituent and its licensor (Bumford and Barker 2013). The sign language data provides a new unique piece to the puzzle: through the use of space, a dependent term is able to overtly specify its licensor.

For example, in (37), the boys are established over locus a on the right, and the girls are established over locus b, on the left. The numeral ONE moves in space over locus b, thus disambiguating that the books depend on the girls.

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

These facts require a system powerful enough to formally represent dependency relations in a way accessible to the compositional semantics.

3.2 Functions in spoken language

As with most cases of reference, perhaps the clearest case of functional reference comes in the form of a pronoun—in this case, in the form of a paycheck pronoun (Karttunen 1969, Jacobson 2000, a.o.). Sentence (38) provides an example:

(38) Every 5 year old boy loves his mother. Every 10 year old boy hates her.
$\langle e, e\rangle$ e

In this pair of sentences, the important pronoun is the word *her*. Of note, we observe that it can't be an individual variable, either bound or free, because, while it co-varies with the noun phrase 'every 10 year old boy,' it doesn't *denote* that boy; rather, it denotes his mother. A standard story (Cooper 1979, Engdahl 1986) is that the meaning of the pronoun comes with two variables: a functional variable retrieved from context (here, 'his mother'), and a bound individual variable, plugged into the function.

Sentence (39) provides a slightly more complex example (called 'quantificational subordination' by Brasoveanu 2006), which will be relevant for us here.

(39) Each boy saw a girl. No boy waved to her.

a. $f_{\langle e,e\rangle} = \lambda x.$ the girl that x saw

In this sentence, again the pronoun *her* denotes a function, with a meaning as in (39a). However, in this case, there is no single constituent (such as 'his mother' in the previous sentence) from which the functional meaning can be retrieved. Such examples have been discussed by van den Berg 1996, Nouwen 2003, and Braoveanu 2006, among others. The basic analysis is that, somehow, a functional antecedent is *constructed* through the interaction of the distributive operator, here 'each boy', and the indefinite, here 'a girl'.

But it turns out that it's not just pronouns where functional reference rears its head. Beyond pronouns, there are many cases where functions are necessary to get the correct truth conditions. These examples, which we'll see in a second, include: (a) functional questions, (b) functional indefinites, and (c) the 'internal' readings of certain adjectives, like *same* and *different*. I'll quickly go through these in spoken language, before turning to the relevant examples in sign language.

The first case is functional questions (including the sub-case of pair-list questions), as discussed by Groenendijk and Stokhof 1984 and Chierchia 1993, among others. The examples of note are question-answer pairs like the ones in (40).

(40) a. **Q:** Which woman does every man love?
A: His mother.

b. **Q:** Which woman does every man love?
A: John – Mary, Bill – Susan, Stephen – Alice.
'What is the function f from men to women such that each man x loves $f(x)$?'

Of note here, the given answers do not denote individuals—they're functions relating one individual to another. On the standard assumption that the meaning of a question is closely related to the meaning of its answers, this means that the questions in (40) have a functional meaning, which are felicitous with functional answer. In (40a), it is the *mother-of* function; in (40b) it is an arbitrary correspondence.

The second case of functional reference involves sentences with an indefinite (Hintikka 1986, Kratzer 1998b Schwarz 2001, Winter 2001, Solomon 2011). An example is given in (41).

(41) a. No boy talks to a certain relative of his about girls. (Namely, his mother.)
'There is a certain function f from boys to relatives such that no boy x talks to $f(x)$ about girls.'

b. If everyone improves in a certain area, then nobody will fail.
'There is a certain function f from students to areas such that, if every student x improves in $f(x)$, then nobody will fail.'

(from Schlenker 2006)

The reading brought out by the continuation in (41a) ("Namely, his mother") requires reference to functional types, as in the gloss below the sentence. Notably, there's no way the arrange the first-order quantifiers *no* and $\exists$ to get this meaning: you actually need to be able to quantify over functions. Sentence (41b), from Schlenker 2006, gives a related, but slightly more complex example; the relevant reading here is one in which the speaker has in mind a certain arbitrary correspondence between students and areas. As in (41a), there is no way to get these truth conditions by only rearranging first-order quantifiers *if*, $\forall$, and $\exists$. Solomon 2011 highlights the connection between the functional indefinite in (41b) and the pair-list question in (40b).

The final examples of functional reference involve *same* and *different*. In this example and in subsequent ones, I will be focusing on the 'internal' reading of these adjectives, which compares the individuals of a plural or distributive licensor. That is, the internal reading of (42a) doesn't mean that the boys read the same book as some other person (like, Mary), but instead, that they read the same book as each other.

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

b. Every boy read a different book.
'The function from boys to the book they read is an injective function.'

Bumford 2014 argues that there are deep connections between internal readings of adjectives and functional readings of indefinites. Without getting into the details of this account, however, let me just observe that the only way to state the truth conditions for the sentences in (42) is by making reference to the boy-book correspondences. This means that a paraphrase in terms of functions, as given above, is very natural way to state the truth conditions. In general, all compositional accounts of *same* and *different* are forced to include mechanisms which fill a similar role (see, e.g. Barker 2007).

In this chapter, I will show that American Sign Language in fact uses space in a similar way for each of these phenomena. I'm going to focus in particular on the case of 'dependent indefinites' and the adjectives *same* and *different*. Ultimately, I will argue that the use of space allows functional dependencies to be made overt.

First, though, let's start with some background on the use of space in ASL.

3.3 The use of space in American Sign Language

As we saw in Chapter 2, in American Sign Language, individuals can be indexed at points in space, or 'loci'. For example, if a signer is talking about some individual, Mike, who's not in the conversation, the signer can index him at a location in space; he or she can then refer back to him later with a pronoun that literally points to the location where Mike was established. Sentence (43) repeats an example from Chapter 2 in which spatial indexing can disambiguate a singular pronoun with two possible antecedents.

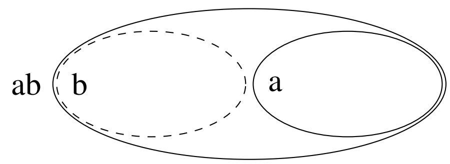
(43) JOHN-a TELL BILL-b IX-{a/b} WILL WIN.
'John$_i$ told Bill$_j$ that he$_{\{i/j\}}$ would win.'

Plural individuals can be associated with areas of space. There are at least two ways of morphologically marking plurals: either with a sweeping 'arc'-motion, or with a repeated or reduplicated movement across the area of space. Below, I will gloss arc-movement as '-arc' and reduplication as '-redup.'

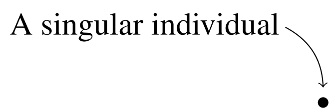
(44) a. Arc-movement

b. Reduplication

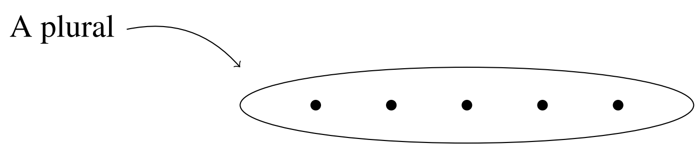
One final point about plurals is relevant to talk about now, since (a) it will be relevant for the argumentation later, and (b) it gives a taste of the increased expressive power that is allowed with the use of space. The basic observation, discussed in depth in Schlenker et al. 2012, is that geometric properties of the *form* of a plural in sign language map onto mereological properties of the *denotation* of the plural. What this means in practice is that when you indicate one plural within the area of another plural, then you infer that the first is a subset of the second. The construction also makes various antecedents available for later plural pronouns. As with spoken language, it introduces a discourse referent for each of the two plurals indicated (the superset and subset). Unlike spoken language, though, it also makes available the complement set; by moving a plural pronoun over (roughly) the difference between the two areas, a discourse referent denoting the complement set—the subset minus the superset—can be retrieved. This discourse referent emerges by virtue of the iconic interaction of the other two plurals. Here, I use notation ‘ab’ to indicate a plural locus that includes both locus a and locus b.



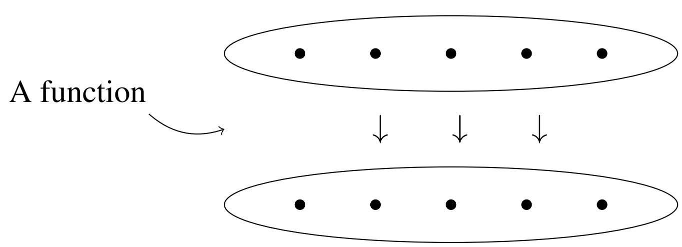
At this point, we have a rather intuitive *graphical* representation of these semantic objects. Singular individuals are represented as points in space.



Plural individuals, we’ve just seen, can be *areas* of space—that is, sets of points.



If that’s the case, then what would we expect a *function* to look like? Well, a function is a relation between two plurals—it’s a map from one plural to another. You could represent it graphically like this:



Here, what I’m going to argue is that this picture that I’ve just sketched should be taken quite literally, and that it is actually very close to way that space can be used to indicate functional reference in American Sign Language. Specifically, functional reference can be established in ASL by indexing two plurals over spatially associated—often co-located—area of space. One of these plurals provides the input of the function; the other plural provides the output of the function.

(45)
$$\begin{array}{cccc} i_1 & i_2 & & i_n \\ \downarrow & \downarrow & \cdots & \downarrow \\ o_1 & o_2 & & o_n \end{array}$$

This spatial representation of functions then allows dependencies to be overtly realized.

The following three examples show this in practice. In (46), the numeral ONE, quantifying over students, moves in space over an area that is previously associated with professors. The resulting interpretation is that it is one student *per professor* who will receive an A.

(46) MANY PROFESSOR IX-redup-a INFORM-ME ONE-rep-a STUDENT WILL RECEIVE A.
'Many professors informed me that one student (each) will receive an A.'

In (47), the adjective SAME, modifying BOOK, moves over the same area of space that was indicated by the quantifier phrase ALL BOY. The resulting interpretation is that the book that each boy read is the same as the book that the other boys read. The sameness is distributed over the boys.

(47) ALL-a BOY READ SAME-arc-a BOOK.
'All the boys read the same book.'

Finally, in (48), the adjective DIFFERENT, modifying BOOK, moves over the same area of space that was indicated by the plural IX-arc-a BOY. The resulting interpretation is that each boy gave the girl a different book from the other boys.

(48) IX-arc-a BOY DIFFERENT-redup-a BOOK a-GIVE-alt-b THAT-b GIRL.
'All the boys gave that girl a different book.'

The following two sections explore each of these constructions in more depth.

3.4 Dependent indefinites

3.4.1 Dependent indefinites in spoken language

In English, the following sentence is ambiguous:

(49) Every dog chased one cat.
$\forall > \exists$ or $\exists > \forall$

This sentence can be interpreted with the universal scoping over the existential—that is, there is a potentially different cat for each dog—or it can be interpreted with the existential scoping over the universal—that is, there is a single unfortunate cat that was chased by all the dogs.

In some languages, the indefinite can be morphologically altered, often through reduplication, with the semantic result that the indefinite must depend on the other operator. Some languages that have these so-called **dependent indefinites**[1] include Hungarian (Farkas 1997, 2001), Romanian (Farkas 2002), Telugu (Balusu 2006), Korean (Choe 1987, Gil 1993), Russian (Pereltsvaig 2008, Yanovich 2005), and Kaqchikel Mayan (Henderson 2014).

[1]The term 'dependent numeral' has also been used somewhat interchangeably to describe the same phenomenon. In some languages, modifying the number 'one' has a slightly different effect than modifying any other number; in these cases, 'dependent indefinites' is sometimes used to refer to the former and 'dependent numeral' to the latter. In ASL, I have observed no differences between the two, so I will use the terms interchangeably.

Example (99) gives a Telugu sentence with the reduplicated numeral *renDu renDu*, 'two two.' Here, the effect of reduplicating the numeral is that the reading where the existential scopes over the universal is eliminated. In fact, Balusu 2006 reports that sentence can only be used if the $\exists > \forall$ reading is not true.

(50) **Telugu** (Balusu 2006)

Prati	pillavaaDu	renDu	renDu	kootu-lu-ni	cuus-ee-Du
Every	kid	2	2	monkey-Pl-Acc	see-Past-3PSg

'Every kid saw two monkeys (each).'

We can state this constraint as the following **variation condition**: dependent indefinites must introduce a non-constant functional witness into the discourse context. That is, in (99), there must be a non-constant function from the kids to the monkeys they saw; the monkeys must vary with respect to the boys.

This can be made precise with an informal but explicit algorithm, illustrated in (51). For a given situation, we make a table listing all the kids and the monkeys they saw; every row of the table contains a kid-monkey pair that was involved in a seeing event. We then divide up the rows of the table with respect to the kids, and compare the sets of monkeys seen by each kid. What it means for the function to be non-constant is that these sets are not all identical.

The table in (51) shows one possible verifying situation for the Telugu sentence in (99). Here, the sets of monkeys are not all the same, so there is a non-constant function from kids to monkeys, and the sentence is felicitous.

(51)

kids	monkeys	
k_1	m_1	Monkeys seen by $k_1 = \{m_1, m_2\}$
k_1	m_2	
k_2	m_1	Monkeys seen by $k_2 = \{m_1, m_2\}$
k_2	m_2	
k_3	m_2	Monkeys seen by $k_3 = \{m_2, m_3\}$
k_3	m_3	

We can compare this situation to what happens if the existential quantifier were to scope above the universal: on this logical form, the only situations verifying the sentence would be ones where the same pair of monkeys was seen by each kid. On this scope-ordering, no situation could satisfy the variation condition, so the logical form would be ruled out.

This algorithm, though informal, is intended to foreshadow the formalism of Dynamic Plural Logic that will be used in Chapter 4 to provide a formal analysis for dependent indefinites. In its current form, however, it should be noted that the generalization faces certain limitations. First, while the algorithm that I have given tells us how to determine if a given situation satisfies the variation condition, it gives no guidance about how to arrive at a set of situations for a particular sentence with a dependent indefinite. Above, I implicitly assumed that the semantic contribution of dependent indefinite, aside from the variation condition, is otherwise identical to that of a plain indefinite. This will work as a rough approximation, but will not extend to cases with SAME and DIFFERENT.

Second, the algorithm that I've described here only looks at sentence-level truth conditions of the output form, so it's not able to see whether the variation condition has been satisfied at a lower level in the derivation. For instance, the Hungarian sentence in (52) provides an example where a dependent indefinite is licensed by a plural that scopes below sentential negation. The truth conditions of the sentence as a whole mean that a single table was lifted by all the boys. Nevertheless, the sentence is felicitous, because the variation condition is satisfied at the level just below the negation.

(52) **Hungarian** (p.c Dániel Szeredi)

A gyerekek nem egy-egy asztalt emeltek fel; kzsen egyet
The kids not one-one table lift.PAST.3PL pfx; together one.ACC
emeltek fel.
lift.PAST.3PL pfx
'The kids didn't lift one table each; they lifted one together.'

Chapter 4 will provide a formal analysis that will make both of these points explicit. In a nutshell, I will say that dependent indefinites require a functional discourse referent to be dynamically accessible at a given point in the (dynamic) evaluation of a sentence. Without going into details here, I take this functional discourse referent to be exactly the function that can be retrieved in cases of quantificational subordination in English, as seen in examples like (39), repeated here in (53).

(53) Each boy saw a girl. No boy waved to her.
  a. $f_{\langle e,e\rangle} = \lambda x.$ the girl that x saw

Anticipating the ASL data, I hypothesize that arc-movement in ASL is available only if quantificational subordination is licit in English. That is, the inflection of ONE in (54) will only be possible in environments where an analogous indefinite in English generates a functional antecedent that can be retrieved by a pronoun, as in (55).

(54) ALL-a BOY READ ONE-arc-a BOOK.
'All the boys read one book.'

(55) All the boys read a book, and all of them liked it.

One final point should be flagged for later: at this point, the reader may wonder whether the variation condition is truly a semantic entailment, or if it could be a pragmatic inference, arising from competition with another form. I will return to this question in §3.6.2; I will ultimately be amenable to the idea that there is some pragmatic reasoning involved; however, I will argue that a competition-based analysis is insufficient to capture the full range of data, so we will still need the general analysis that I develop here.

3.4.2 Dependent indefinites in ASL

In American Sign Language, the uninflected form of a numeral is signed by holding a hand in place; in this form, ASL indefinites generate scope ambiguities just like English indefinites. In ASL, though, numerals may additionally move in space (with either arc-movement or reduplication) over an area associated with another plural. Sentence (56) gives an example. Here, we see EACH-EACH PROFESSOR indexed over the area at locus a; ONE, preceding STUDENT, is then reduplicated over the same area of space.

(56) EACH-EACH-a PROFESSOR NOMINATE ONE-redup-a STUDENT.
'Each professor nominated one student.' ($\forall > \exists$ only)

This plural inflection may be applied to any numeral that doesn't specify a movement on the uninflected form (i.e. the numbers 1 to 9). The semantic effect of this plural inflection is the same as that of dependent indefinites in other languages: only the $\forall > \exists$ reading is possible for the sentences. For example, in (56), the only possible reading is one in which there is one student nominated per professor.

Kimmelman 2015 reports an analogous finding in Russian Sign Language: in RSL, numerals may be reduplicated over an area of space, with a distributive interpretation. Thus, the RSL sentence in (57) means that each man bought one beer.

(57) **RSL** (Kimmelman 2015)[2]
$\overline{\text{MAN IX BUY BEER}}^{\text{TOP}}$ ONE-redup.
'The men bought one beer each.'

Thus, the behavior of inflected numerals in both the ASL and RSL fits perfectly into a pattern that is familiar from spoken language. Additionally, though, there is the added role of space: numerals with plural inflection must move over an area associated with another plural in the sentence.

The remainder of the section will proceed as follows. First, I will confirm that numerals with plural inflection must move over the area of their licensor. I will show that this area concurrently indexes both plurals. I will then present facts about the licensing of dependent indefinites in ASL; these will fall out nicely from the variation condition proposed in §3.4.1. Finally, putting the licensing facts together with the spatial properties, I will turn to cases with multiple possible licensors. The result will be that ASL is able to disambiguate readings where spoken language cannot.

In Section 3.5, I will repeat the same process for SAME and DIFFERENT.

3.4.3 Two plurals, one locus

First, I will argue that the plural motion of a numeral plays a double role: it establishes the locus of the NP that it attaches to (e.g. the students in (56)), but it also agrees with the locus

[2] Kimmelman glosses the dependent numeral as $\text{ONE}_{\text{distr}}$; I have adjusted notation here to match my own. The translation is also my own, based on Kimmelman's description.

of another plural in the sentence (e.g. the professors in (56)). A correlate of this claim is the fact that two plurals may end up simultaneously located over the same area of space. As we saw in Chapter 2, Kuhn 2015 argues that in general non-coreferential NPs may share a single locus, especially when motivated by pragmatic association. Under the current claim, dependent indefinites would comprise a new piece of evidence in favor of the generalization in Kuhn 2015.

Empirically, if two NPs are co-located, then pointing to their locus should be able to retrieve either NP. The examples in (58) and (59) provide evidence that this is indeed the case in constructions with dependent indefinites. Here, both sentences start out the same way, with the motion of ONE indexed over the same locus as motion of EACH. The two sentences differ, though, in their continuation: in (58), the anaphoric, plural sign IX-arc-a is combined with an NP that indicates that the space indexes the professors. In (59), the same anaphoric sign occurs, but it's identified as indexing the students.

(58) EACH-a PROFESSOR SAID ONE-arc-a STUDENT WILL RECEIVE A. <u>IX-arc-a</u> PROFESSOR WILL HAPPY.
'Each professor said one student (per professor) will receive an A. The professors will be happy.'

(59) EACH-a PROFESSOR SAID ONE-arc-a STUDENT WILL RECEIVE A. <u>IX-arc-a</u> STUDENT WILL HAPPY.
'Each professor said one student (per professor) will receive an A. The students who got an A will be happy.'

The interpretation of the first sentence is that the professors will be happy; the interpretation of the second is that the students who receive an A will be happy. These examples show that ONE-arc is able to establish the locus of the NP it attaches to over the same locus as a plural NP earlier in the sentence.

Nevertheless, the skeptical reader might wonder whether the sign IX-arc-a in (59) is truly indexing the students, or whether it could still be indexing the professors, interpreted possessively as 'their students.'[3] As it turns out, conclusive evidence against this counter-analysis comes from examples with complement set anaphora. In particular, we observe that the NP attached to ONE-arc may feed complement set anaphora, as for any ASL plural with structural iconicity, just as we saw before. Sentence (60) gives an example. Here, the students are indexed over a large area of space (locus ab), then a dependent numeral, dependent on EACH STUDENT, is indexed over a subset of that area (locus a). By pointing to the superset area, the subset area, or the complement set area, a subsequent sentence can be interpreted in one of three ways: either all the students will be happy, the students who get a B will be happy, or—the complement set anaphora reading—the students who *don't* get a B will be happy.

[3]In general, possessive structures are constructed with the possessive pronoun POSS, but Chen Pichler & Hochgesang 2009 report that the personal pronoun IX may sometimes appears with a possessive meaning, such as with kinship terms and body part possession, though they remain agnostic about whether IX is actually acting as a true possessive in these structures.

(60) STUDENT IX-arc-ab, EACH-a PROFESSOR SAID ONE-arc-a STUDENT WILL RECEIVE B.

a. IX-arc-ab STUDENT WILL HAPPY.
   'All the students will be happy.'

b. IX-arc-a STUDENT WILL HAPPY.
   'The students *who get a B* will be happy.'

c. IX-arc-b STUDENT WILL HAPPY.
   'The students *who don't get a B* will be happy.'

The only way that the complement set could come into existence is if ONE-arc-a has established the set of students at locus a. Thus, a dependent indefinite establishes the locus of the NP that it attaches to.

The flip side of the coin, though, is that a dependent indefinite must also be spatially associated with the locus of the plural that is dependent on. The data that we have seen above show that this spatial association *can* occur; furthermore, by looking at the interpretation of sentences without spatial association, we show that it *must* occur. One such example is given in (61), where the professors are indexed on the right, and ONE-arc moves over a space on the left. The sentence is judged as acceptable (6/7 on a seven-point scale), but the interpretation has now changed, relying on the existence of contextually salient groups that have already been defined for the speaker and addressee. The dependent indefinite picks out one student from each of these groups. Notably, the sentence lacks the interpretation where the students depend on the professors.

(61) EACH-a PROFESSOR SAID ONE-redup-b STUDENT WILL RECEIVE B.
     'Each professor said that one student *from each contextually salient group* will receive a B.'

Thus, we observe that dependent indefinites *require* spatial association with their licensor.[4]

3.4.4 Licensing

In this section, we address what can serve as the licensor for a dependent indefinite. The generalizations are as follows: bare plurals can license dependent indefinites; distributive quantifiers like ALL and EACH can license dependent indefinites. Singular individuals cannot license dependent indefinites. Finally, the quantifier NONE cannot license dependent indefinites. These generalizations are exemplified in (62a)–(62d).

[4] Must these two plurals be co-located, or can they be separated if they remain spatially associated in some way? Preliminary results suggest that spatial association may be sufficient, but only in certain spatial configurations. As we have seen in (61), separation along the x-axis from right to left does not allow a dependent interpretation. Separation along the y-axis, with the dependent indefinite indexed *above* its licensor is also not possible. However, separation along the z-axis may be possible: a dependent indefinite may be established *in front of* its licensor and still retain a dependent interpretation. Pronouns can then point to either location to unambiguously pick out the input or the output of the function. However, since the use of the z-axis in ASL has not been explored in depth, I remain cautious in interpreting this result.

(62) a. BOYS IX-arc-a READ ONE-arc-a BOOK. plural
'The boys read one book each.'

b. ALL-a BOYS READ ONE-arc-a BOOK. all
'All the boys read one book (each).'

c. * BOYS IX-arc-a, NONE READ ONE-arc-a BOOK.[5] none

d. * JOHN-a READ ONE-arc-a BOOK singular

We can understand these generalizations in light of the variation condition described in §3.4.1. Turning first to plural and distributive operators, the explanation is clear: in both cases, a plurality of boys are introduced by the licensor; the scenario on which they each read their own book is one which may introduce a non-constant function and satisfy the variation condition. The case of a singular subject is also straightforward: if only one boy read a book, then there is only one book involved, so the variation condition can never be satisfied.[6]

Perhaps most surprising is the fact that ONE-arc is not grammatical under the quantifier NONE, even though (a) NONE quantifies over a dynamically accessible plurality of boys and (b) there is a quantifier that can take scope over the dependent indefinite. As it turns out, though, this fact can also be explained through the requirement of a non-constant functional witness.

The situation can be understood by considering the truth conditions for a sentence where a (plain) indefinite scopes under a universal quantifier compared to those for a sentence where an indefinite scopes under *none*. Intuitively, if every boy read a book, then there is a correspondence between the boys and the books they read. In contrast, if no boy read a book, there is no such mapping from boys to books. Purely mechanically, if we follow the algorithm described in §3.4.1 and construct a table for a situation that verifies the sentence 'none of the boys read a book,' we will end up with an empty table, since there are no boy-book pairs in the reading relationship.

Finally, in §3.4.1, I claimed that arc-movement is only licensed in ASL in those contexts where functions are dynamically accessible to quantificational subordination in English. This prediction is borne out in the contrast between *all* and *no* in (64).

(64) a. Each student read a book. They each liked it. ($\forall > \exists$)

b. * No student read a book. They each liked it. (None $> \exists$)

Thus, dependent indefinites are licensed exactly by those operators that are able to introduce a non-constant function into the discourse context.

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[5]As a control, the same sentence with no inflection on the indefinite is grammatical, with the meaning that no boys read any books.

(63) BOY IX-arc, NONE IX-arc READ ONE BOOK.
'None of the boys read a book.'

[6]One puzzle is the fact that dependent indefinites can be licensed by operators that distribute down to atomic individuals, like EACH in (58). The puzzle here is that there is no way to satisfy the variation condition if the dependent indefinite only has access to a single individual. This puzzle forms the crux of a large amount of

3.4.5 Multiple licensors

Finally, we turn to cases where the use of space in ASL is able to disambiguate sentences in ways not possible for spoken language.

Because the motion of the numeral must be spatially associated with the licensor—i.e the input of the function—we can specify *what the numeral is dependent on*. The critical cases will be those in which a sentence has two potential licensors. Sentences (65) and (66) give examples from Hungarian and Albanian.[7]

(65) **Hungarian** (p.c. Dániel Szeredi; two speakers)

A fiúk két-két könyvet adtak a lányoknak.
The boys two-two book give.3Pl the girls
'The boys gave the girls two books each.'

(66) **Albanian** (p.c. Bujar Rushiti)

Djemtë u dhanë vajzave nga dy libra.
boys 3Pl.Dat gave girls DIST two books
'The boys gave the girls two books each.'

In Hungarian, dependent indefinites require licensing by a plural or distributive operator, but there is no morphological marking that specifies what this licensor is. Thus, sentence (65), with two potential licensors, *két-két*, 'two-two,' could in principle depend on either the boys or the girls. This is borne out: the sentence in (65) may be true in a scenario in which the boys collectively gave one book to each of the girls, and also in a scenario in which the girls collectively received one book from each of the boys. The example in (66) provides an analogous example in Albanian: the dependent indefinite *nga dy* ('DIST-two') may be licensed by either plural: the sentence is true in exactly the same scenarios as the Hungarian example. (The two are also true in the third scenario where each boy gave each girl two books.)

In contrast, in ASL, the two licensors can be located over two different areas of space. The numeral then can agree with either area, with the result of disambiguating the meaning. Sentence (67) provides an example.

(67) ALL-a BOY-a GIVE ALL-b GIRL-b ONE-redup-b BOOK.
'All the boys gave all the girls one book (per girl).'

Here the boys are indexed over locus a, the girls are indexed over locus b; ONE then moves in space over locus b, where the girls were indexed. The resulting inference is that there is a (non-constant) function from girls to the books they received. To unpackage this meaning, let us focus on two specific cases, where either the boys or the girls acted collectively. Other

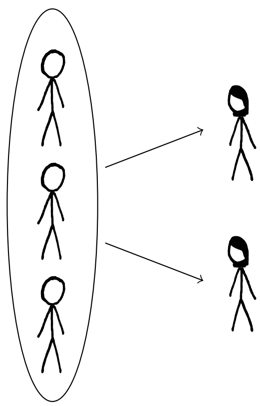
theoretical work (see, e.g., Henderson 2014), and is a central concern of Chapter 4. Essentially, the solution is to allow the variation condition to take scope outside of the distributive operator in order to see the full set of individuals. We set this aside for now.

[7]Thanks to Daniel Szeredi and Bujar Rushiti for extremely thorough and insightful discussion on these sentences and others.

readings are also available (e.g. the one in which each boy gave each girl a book), but the point is clearest if we set these aside for now.

First, consider a situation in which the boys collectively gave books to the girls; for example, the boys as a group gave Mary one book and gave Elizabeth one book. This situation is illustrated in (69a). In (69b), I represent this in table form, where each row represents a boy-girl-book triplet that was involved in a giving event. When we look at the sets of books given to the two girls, we see that they are different sets, so there is a non-constant function and the reading is licensed.[8]

(69) a.

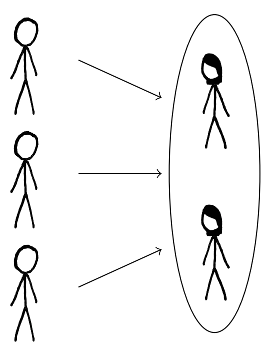


b.

boys	girls	books	
b_1	g_1	o_1	Books given to $g_1 = \{o_1\}$
b_1	g_2	o_2	
b_2	g_1	o_1	Books given to $g_2 = \{o_2\}$
b_2	g_2	o_2	
b_3	g_1	o_1	
b_3	g_2	o_2	

Second, consider a situation in which the girls collectively received books from the boys; for example, John gave the group of girls one book, Bill gave the group of girls one book, and Eric gave the group of girls one book. This situation is illustrated in (70a). In (70b), I represent this in table form, as above. When we look at the sets of books given to the two girls, we see that they are the same set, so the reading is *not* possible.

(70) a.



b.

boys	girls	books	
b_1	g_1	o_1	Books given to $g_1 = \{o_1,o_2,o_3\}$
b_1	g_2	o_1	
b_2	g_1	o_2	Books given to $g_2 = \{o_1,o_2,o_3\}$
b_2	g_2	o_2	
b_3	g_1	o_3	
b_3	g_2	o_3	

A similar example exists where ONE agrees with the boys, with the opposite interpretation: true for (70) but not for (69). It should be noted, however, that when there are two possible

[8]Possibly a more perspicuous way to represent this situation in a table would be with sum individuals, as in (68). Note that this produces exactly the same results.

(68)

boys	girls	books	
$b_1 \oplus b_2 \oplus b_3$	g_1	o_1	Books given to $g_1 = \{o_1\}$
$b_1 \oplus b_2 \oplus b_3$	g_2	o_2	Books given to $g_2 = \{o_2\}$

quantifiers that a ONE can be dependent on in the same sentence, there is a preference for the numeral to depend on the closest one. Thus, the sentence in (71), minimally different, from the one in (67), receives a slightly degraded judgment: on a seven point scale where 7 is best, it receives a 5/7. Nevertheless, the meaning of this sentence is clear, and, if the sentence order is changed, as in (72), then the example becomes perfect: 7/7.

(71) $^{5/7}$ ALL-a BOY-a GAVE ALL-b GIRL-b ONE-redup-a BOOK.
'All the boys gave all the girls one book (per boy).'

(72) EACH-a BOY-a ONE-redup-a BOOK GAVE ALL-b GIRL-b.
'Each boy gave one book to all the girls.'

In these examples, ASL goes beyond other languages with dependent indefinites in its ability to disambiguate dependencies. In order to express this meaning, we need to make reference to functions.

3.5 SAME and DIFFERENT

Turning to the adjectives SAME and DIFFERENT, we see exactly the same patterns as we did for dependent indefinites. SAME and DIFFERENT may move over an area of space associated with an appropriate licensor. Just as for dependent indefinites, possible licensors include bare plurals and distributive operators, but do not include singular nouns or the quantifier NONE. When two possible licensors exist in a sentence, the movement of SAME and DIFFERENT can disambiguate the meaning of the sentence where spoken language cannot.

3.5.1 SAME agrees with its licensor

ASL has several words that translate roughly as 'same.' One of these words is signed with a Y handshape; this can be signed with a small, neutral motion, but it can also move in space to agree with a plural locus. Agreement specifies the things which are the same.

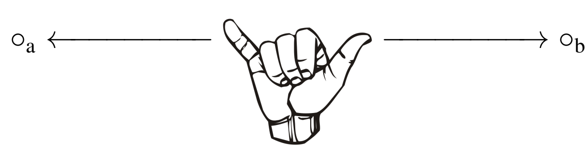


Figure 3.1: ASL SAME agreeing with two singular loci.

Sentence (73) provide a simple example that demonstrates the flexibility of this agreement. Here, the thumb points to the floor, the pinky to the ceiling, and the motion is a vertical one.

(73) CEILING AND FLOOR SAME-up/down COLOR.
'The ceiling and the floor are the same color.'

Sentence (74) provides an example of SAME under the licensor ALL BOY. Here, SAME can either be signed with a neutral motion or with an arc-movement that moves over the plural locus that was introduced by the licensor. Both forms allow the internal reading that the books that any two books read were the same.

(74) ALL-a BOY READ SAME{-neutral/-arc-a} BOOK.
'All the boys read the same book.'

As with dependent indefinites, when SAME moves in space, it must be spatially associated with the plural that licenses it. This can be seen in the ungrammaticality of sentences that have a locus mismatch. In sentence (75), of the two NPs that establish loci, only the plural one is able to license SAME-arc. Therefore, SAME-arc must occur over the locus where the boys are indexed, and not at the locus where the singular girl is indexed.

(75) a. ALL BOY-a a-GIVE-alt-b THAT GIRL-b SAME-arc-a BOOK.
'All the boys gave that girl same book.'

b. * ALL BOY-a a-GIVE-alt-b THAT GIRL-b SAME-arc-b BOOK.

In the functional terms that we have been using thus far, we can say SAME entails a constant function (here, from boys to books); when SAME moves in space, then arc-movement must agree with the input of this function.

3.5.2 No licensing of SAME by singulars

Turning to licensing, we observe that (the internal reading of) SAME cannot be licensed by a singular noun, as seen in the ungrammaticality of (75b) above. In fact, this is no different from English *same*. For example, we cannot interpret (76) with an internal reading, even though we can imagine what such a reading would be: 'there is a constant function from the elements of the set {John} to the books that they read.' In other words, the sentence should be equivalent to 'John read a book.'

(76) * John read the same book.
(Ungrammatical on internal reading)

In §3.4, I accounted for the ungrammaticality of dependent indefinites under singulars by requiring there to be a non-constant function from the individuals introduced by the licensor to the individuals introduced by the dependent noun phrase; here, however, that strategy seems doomed to fail, since the meaning of *same* is exactly that the function in question *is* constant.

As it turns out, the literature on *same* in English provides a solution. Specifically, a number of authors have observed that the adjective *same*, on both the external and internal readings, presupposes the existence of a plurality of events (Carlson 1987, Barker 2007, Hardt et al. 2012, Hardt and Mikkelson 2015). A convincing example involving an external reading of *same* comes from Hardt et al. 2012, who observe that *same* is not grammatical in (77b), in which both sentences describe a single reading event.

(77) a. I read War and Peace on my last vacation, and I read it in a single sitting.

b. * I read War and Peace on my last vacation, and I read the same book in a single sitting.

(from Hardt et al. 2012)

Barker 2007 makes a similar point for sentences with internal readings of *same*. He observes that (192) only admits the reading in which John's buying and Mary's selling are not part of the same exchange.

(78) John bought and Mary sold the same book. (from Barker 2007)

a. 'There were two events: one in which John bought the book and one in which Mary sold it.'

b. * 'There was one event in which Mary sold John a book.'

Translating this observation to the current domain, we are presented with a solution: SAME in ASL (and presumably also *same* in English) requires there to be a non-constant function from its licensor *to a set of events*. A singular noun cannot license SAME because there's only one input to the function, so there is only a single output event.

In addition to providing a solution to the singular licensing puzzle, this move also begins to unify the contribution of arc-movement in the case of dependent indefinites and the case of SAME: now both can be seen as involving non-constant functions. I discuss the implications of the move to event semantics further in §3.6.2, where I suggest that even the case of dependent indefinites may be better viewed as involving a function from the licensor to events.

3.5.3 SAME under NONE

Next, we turn to SAME under NONE. Recall that ONE-arc and other dependent indefinites in ASL are ungrammatical under NONE. On the other hand, note that *same* in English is perfectly fine under *none*, as seen in (79). It's not entirely clear, then, what to expect from the ASL data.

(79) None of the boys read the same book.

It turns out that ASL SAME reflects *both* of these patterns, in a paradigm that hinges critically on the presence or absence of arc-movement. When SAME is signed neutrally, it may be licensed by NONE, patterning with *same* in English. On the other hand, when SAME is inflected with arc-movement, it becomes ungrammatical under NONE, patterning with dependent indefinites in ASL—in other words, with the other instance of arc-movement on a noun modifier. The contrast is illustrated in (81), with (80) providing a control with ALL.

(80) THAT CLASS IX-arc, ...

a. ALL STUDENT READ SAME-neutral BOOK.

b. ALL STUDENT READ SAME-arc BOOK.
'All the students read the same book.'

(81) THAT CLASS IX-arc, ...

a. NONE STUDENT READ SAME-neutral BOOK.

b. * NONE STUDENT READ SAME-arc BOOK.
'No students read the same book.'

This example provides us with a clean minimal pair isolating the semantic contribution of the arc-movement. Based on the data that we have seen up to this point, I have argued that arc-movement is responsible for specifying the input of a function. Using the same insight, we can provide a sketch of what is going on in (81).

In general terms, the arc-movement in (81b) indicates the existence of a function from the boys to a plurality of reading events that all contain the same book. However, given the truth conditions of SAME under NONE (i.e. the same truth conditions as for (79)), no such plurality exists, yielding ungrammaticality.

As we try to make this more precise, however, the situation becomes a little more complex. Specifically, the sentence (81a), like its English counterpart in (79), *does* entail (in fact, presuppose) that each boy read a book—the books are just all different. The informal system that I provided in §3.4.1 to check the existence of a non-constant function (to events or to individuals) is based solely on the truth-conditions of a sentence; it thus breaks down in this case, satisfied by the existence of the presupposed plurality of reading events.

But in §3.4.1, I also introduced a second, empirically-based diagnostic to test whether a functional discourse referent was dynamically accessible: namely, the availability of quantificational subordination in English. It turns out that this test supports the hypothesis that there is no dynamically accessible function from books to boys. The examples in (82) provide a minimal pair: the first sentence in both examples are true in exactly the same set of scenarios. Nevertheless, (82a) allows quantificational subordination; (82b) does not.

(82) a. All the boys read a different book, and all of them liked it.

b. * No boys read the same book, and all of them liked it.

What the English examples show is that—at the sentence level—there is no accessible function from boys to books generated by the construction in (82b).[9] I take the ungrammaticality of arc-movement in an analogous environment as evidence that arc-movement, too, is sensitive to the presence of a functional discourse referent at the level at which the sentence is evaluated.

There are many more questions to ask about the dynamics of *none* and of *same*; I leave these open for future work.

[9]Connecting this to a debate that was introduced in Chapter 2, the minimal pair in (82) can potentially serve as evidence in favor of dynamic semantics over an E-type theory, since the minimal situations verifying the two sentences are identical; meaning that the same set of individuals should be recoverable from each of them. Note, in particular, that replacing the pronoun in (82b) with a full definite description is perfectly grammatical.

(83) No boys read the same book, but all of them liked the book they read.

3.5.4 Multiple licensors

Finally, we turn to examples with multiple licensors, where SAME in ASL, like ONE-arc and other dependent indefinites, can disambiguate readings.

In English, Bumford and Barker 2013 observe that sentences with *same* are ambiguous when they appear in sentences with two potential licensors (i.e. two plural or distributive nouns). For example, sentence (84) can receive two readings, depending on whether *same* associates with the licensor *every boy* or the licensor *every girl*. Association with *every girl* produces an 'unimaginative boys' reading, where each boy bought many copies of a single book: John gave every girl the same book; Bill gave every girl the same book, and so on. Association with *every boy* produces an 'unlucky girls' reading, where each girl ends up with many copies of a single book: every boy gave Sally the same book; every boy gave Elise the same book; and so on.

(84) Every boy gave every girl the same book.

The existence of this ambiguity turns out to be of importance for existing semantic analyses of *same* and *different*. Specifically, Bumford and Barker 2013 show that Brasoveanu 2011's analysis of *different* predicts that *different* should obligatorily associate with the closest distributive operator to take scope over it. They further show, through examples with bound pronouns, that an ambiguity like the one in (84) cannot be explained as a matter of the scopal ordering of the two distributive operators. The continued existence of the ambiguity in these sentences means that the analysis in Brasoveanu 2011 undergenerates readings.[10]

In ASL, the fact that space shows overt dependencies allows the signer to disambiguate the sentence. The example in (85) should look very similar to the parallel example with dependent indefinites in (67).

(85) BOYS IX-arc-a EACH-rep a-GIVE-alt-b ALL-b GIRL-b SAME-arc-b BOOK.
'Each boy gave all the girls the same book.'

Here, SAME agrees with the area over which the girls are indexed, so the sentence is interpreted unambiguously with the first reading—the unimaginative boys—where, for each boy, there is a constant function from the girls to the book that they received from that boy.

3.5.5 DIFFERENT

The patterns that DIFFERENT displays are essentially the same as for indefinites and SAME, so I will cover them very briefly. In ASL, DIFFERENT has two forms; the neutral form is signed

[10] It so happens that Henderson 2014's analysis of dependent indefinites makes exactly the same empirical prediction as Brasoveanu 2011's analysis of *different*, though for different reasons. Specifically, the variation condition proposed by Henderson 2014 (analogous to the one proposed here) is obligatorily evaluated at the closure of a distributive operator; this feature is necessary in order to rein in the mechanism of 'post-suppositions' that he uses for scope-taking. The data reported in (65) thus provide a potential argument against Henderson's account, although I interpret this result with caution, since I have not yet carried out all of Bumford and Barker 2014's controls on the scopal ordering of the two distributive operators. This fact will be returned to briefly in Chapter 4.

once by separating the two hands, as in Figure 3.2. A plural form, DIFFERENT-rep is signed by reduplicating the motion of the singular across an area of space.

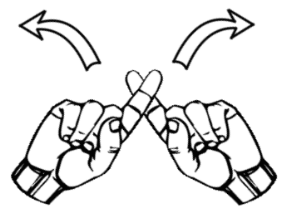


Figure 3.2: Uninflected DIFFERENT in ASL.

One property that distinguishes reduplicated DIFFERENT from dependent indefinites and SAME-arc is that DIFFERENT-rep may appear without a licensor, as seen in the grammaticality of (86). The resulting interpretation in such a case is that there is a plurality of items which are all (or mostly all) different kinds of things. Interestingly, this seems to be analogous to a reading of English plural *different* (e.g. 'a lot of different things'), which likewise doesn't require a licensor.

(86) JOHN-a READ DIFFERENT-redup-b BOOK. IX-arc-b INTERESTING.
'John read an assortment of different books. They were interesting.'

Nevertheless, when DIFFERENT-rep *is* signed over the area of a possible licensor, the result is to disambiguate the dependent reading. The sentences in (87) and (88) provide an example. Focusing only on readings in which the quantifiers THREE BOYS and NINE GIRLS are interpreted cumulatively, the two sentences are judged to have different meanings. For (87), where DIFFERENT-rep moves across the space where the nine girls are indexed, the sentence entails the existence of nine different books, one for each girl. In contrast, for (88), where DIFFERENT-rep moves across the space where the three boys are indexed, multiple girls could have received the same book, as long as a different set of books was chosen by each boy.

(87) [THREE BOYS]-a a-GIVE-GIVE-b [NINE GIRLS]-b DIFFERENT-redup-b BOOKS.
'Three boys gave nine girls books that were different *with respect to the girls.*'

(88) [THREE BOYS]-a a-GIVE-GIVE-b [NINE GIRLS]-b DIFFERENT-redup-a BOOKS.
'Three boys gave nine girls books that were different *with respect to the boys.*'

3.6 Loose ends: dependent indefinites

Chapter 4 will develop a formal analysis for the proposal sketched here, focusing in particular on dependent indefinites. Before we charge head-first into those technical details, however, two basic general points should be addressed regarding dependent indefinites as a sanity check that we are generally on the right path. First, I will compare the analysis presented here to a scope-based analysis; a wide range of data will show that the latter is not viable. Second, I will discuss the role of implicature in the interpretation of dependent indefinites; I will conclude that there is a component of implicature but that it doesn't undermine the general analysis.

3.6.1 Competing analysis: 'Dependent indefinites scope low'

In my initial presentation, I characterized dependent indefinites with respect to their scopal properties: when a dependent indefinite appears under a universal quantifier, it necessarily takes narrow scope. My subsequent proposal, however, was implemented not as a matter of scope itself, but in terms of a variation condition that checked that certain output conditions were met (namely, the presence of a non-constant functional witness).

In this section, I consider an alternate hypothesis that directly analyzes dependent indefinites in terms of narrow scope. The hypothesis in (89) can be taken as a literal syntactic constraint (e.g., Oh 2001, 2005, Kimmelman 2015), or as a structural condition that must be met to satisfy some semantic condition (e.g., Farkas 1997, Brasoveanu & Farkas 2011).

(89) **Scope hypothesis for dependent indefinites**
Dependent indefinites must take narrow scope with respect to a distributive operator.

I will argue (following Henderson 2014) that this hypothesis can be shown to be incorrect on a number of fronts.

1. In ASL, NONE does not license dependent indefinites; (some) scopal analyses predict this should be acceptable. (=overgeneration)

2. Henderson 2014: Pluractionals in Kaqchikel Mayan can be shown not to be distributive operators, but nevertheless license dependent indefinites. (=undergeneration)

3. Dependent indefinites licensed by plurals may be conjoined with an indefinite interpreted cumulatively, showing that there is no distributive operator. (=undergeneration)

4. In ASL, dependent indefinites show strong parallels with SAME and DIFFERENT. The truth conditions for these terms independently motivate mechanisms that can manipulate functional relationships. (=parsimony)

First, as we have seen, though, dependent indefinites in ASL are not licensed by NONE. If the only requirement to license a dependent indefinite were the need to scope under another operator, then we would incorrectly predict these sentences to be grammatical. For example, Brasoveanu and Farkas 2011 provide an analysis in which indefinites are interpreted *in situ*, and receive their apparent scope by selecting what quantifiers they can be dependent on. A dependent indefinite is defined by the condition that it cannot be independent from everything (essentially, that it cannot take widest scope). Although no definition is provided for the quantifier *no*, the fact that a plain indefinite is able to specify its scope with respect to *no* entails that scoping below *no* should be sufficient to license a dependent indefinite. As we have seen, this is not the case, and the analysis overgenerates.

Next, we turn to three cases of undergeneration, where the scope-based analysis predicts that dependent indefinites should not be licensed in contexts where they are in fact grammatical.

Henderson 2014, discussing pluractionality in Kaqchikel Mayan, observes that a pluractional morpheme can never make a plain indefinite dependent. The contrast in (90) demonstrates this point: in Kaqchikel, the overt distributive operator *q'ij qij* ('every day') can scope over the indefinite *jun wuj* ('a book') with the meaning that there is a different book on each day. The pluractional suffix *la'* may also indicate an event recurring over time, but the book involved cannot vary over the different occasions.

(90) **Kaqchikel** (Henderson 2014)

a. Q'ij qij xukanöj jun wuj.
day day search a book
'Every day she looked for a (different) book.'

b. Xukano-la' jun wuj.
search-LA' a book
'She looked for a (particular) book many times.'

Henderson takes this as evidence that pluractional inflection in Kaqchikel is not a distributive operator. Instead, he posits that it is a predicate that checks that there is a plurality of events in the denotation of the verb. Nevertheless, Henderson shows that pluractional inflection is able to license a dependent indefinite (such as *ju-jun*, lit. 'one-one') in Kaqchikel.

(91) **Kaqchikel** (Henderson 2014)

a. Xinkan-ala' **ju-jun** wuj.
search-ALA' one-one book
'I looked for a book (in each location or at each time).'

Henderson argues that this is thus a case of licensing without a distributive operator, and a counterexample to the hypothesis in (89).

A second case where dependent indefinites are licensed without a distributive operator can be seen in cases with plural licensors. In principle, plural licensors may come with a covert distributivity operator that can take scope over dependent indefinites in their complement. However, the presence of a covert distributivity operator can be ruled out if another indefinite in the verb phrase is interpreted cumulatively.

Examples (93) and (94) provide such sentences from Tamil and Hungarian, where the dependent indefinite is conjoined with a plain indefinite that is interpreted cumulatively. Whatever syntactic analysis is chosen for coordination structures (e.g. Right Node Raising, etc.), Geach 1970 shows that no new readings emerge from reconstruction of silent syntactic material.[11] Thus, if the dependent indefinite scopes under a distributive operator, then the plain indefinite must as well, and the sentence is predicted to yield truth conditions with twice as many desserts as students. This is incorrect; if there are three students, the sentence entails that they ended up with two desserts on the table, not six.

(93) **Tamil (Chennai dialect)** (p.c. Anushree Sengupta)

Mānavarkkal thankalai kaga **oru-oru** appetizer o irenDu desserts share-panna
students themselves for one-one appetizer and two desserts share-do
order pannagu.
order did
'The students ordered one appetizer each for themselves and two desserts to share.'

(94) **Hungarian** (p.c. Dániel Szeredi)

A diákok két előételt és **egy-egy** főételt rendeltek.
The students two appetizers and one-one main dish ordered.
'The students ordered two appetizers in total, and N main dishes where N is the number of students'

Importantly, this also cannot be explained as a case of wide scope of the plain indefinite (exceptional or otherwise), since scoping an indefinite from under a distributive operator does not give rise to cumulative readings. This becomes clear if we consider a sentence with an overt distributivity operator, as in (95). Here, even if the indefinite *two appetizers* scopes above the distributive quantifier *each student*, the sentence does not generate a cumulative reading; there must still be twice as many orders as students, and the nature of an 'ordering' event means that you end up with as many dishes as orders (even if there are only two *kinds* of dish ordered).

(95) Each student ordered two appetizers for the table.

Thus, plural licensors provide a second instance of licensing without a distributive operator.

Finally, one thing that I have tried to emphasize in this chapter is the overwhelming morphological similarity between dependent indefinites and the adjectives SAME and DIFFERENT. The truth conditions of *same* and *different* (in English as in ASL) are too complex to explain merely as a matter of low scope; instead, some mechanism must be introduced that allows reference to the relation between the licensor and the NP the adjective modifies. An explanation of dependent indefinites by scope alone draws allows no extensions to *same* and *different*, and thus completely misses the generalization from ASL.

3.6.2 Is the variation condition an implicature?

Throughout this chapter, I have developed a theory based on a variation condition that requires there to be a non-constant function from the set associated with the licensor to the set associated with the dependent indefinite. This condition was based in part on the observation that,

[11] Geach specifically discusses examples of right-node raising; for example, the sentence in (92), from Steedman 2009, has only two meanings, not four.

(92) Everyone loves, and everyone hates, someone.

cross-linguistically, sentences with dependent indefinites can generally not be used in situations where the $\exists > \forall$ scope-ordering is true. However, we may well wonder where this inference comes from—is it is hard-wired as a semantic entailment, or is it an implicature, arising through pragmatic competition with another logical form?

Here, I provide evidence that shows that the variation condition does seem to be an implicature—but only in part. In particular, even if we introduce a pragmatic component to our system, it will not be sufficient to capture the range of data that we have seen here; most notably, we will be unable to draw a connection to the paradigms with SAME and DIFFERENT. In contrast, I will show that if we weaken the variation condition to a be condition on *events*, then we can weaken the semantic entailments in an appropriate way, but still derive the results about licensing and SAME/DIFFERENT.

There are several standard tests to see if something is an implicature or an entailment. First, implicatures are cancelable: in an appropriate context, they can be denied without contradiction. Second, implicatures disappear in downward entailing environments, which flip their semantic strength with respect to that of their pragmatic competitor. In ASL, both of these tests suggest that the condition that individuals must vary is in fact an implicature.

Example (96) provides a context in which the variation of individuals is canceled. The final sentence entails that all the books were the same, but the discourse does not yield a contradiction.

(96) PROFESSOR ANNOUNCE STUDENT NEED READ ONE, TWO BOOK. HAPPEN, ALL BOY READ ONE-arc-a BOOK. REAL-BUSINESS IX-arc-a CHOOSE SAME-arc-a BOOK
'The professor announced that the students need to read one or two books. What happened was that all the boys read one book. In fact, they chose the same book.'

Example (97) provides an instance of a dependent indefinite in a downward entailing environment. The sentence is slightly degraded (6/7), with the comment that the 'if ..., then...' construction shows English influence. Nevertheless, the interpretation that is given is that the speaker will be happy if each boy reads two books, even if these happen to be the same two books.

(97) IF ALL-a BOY READ TWO-arc-a BOOKS, ME WILL HAPPY
'If all the boys read two books, I will be happy.'

Could a competition-based analysis alone account for the distribution of dependent indefinites? Henderson 2014 dismisses this possibility, observing that standard theories allow implicatures to be canceled, so competition should not be strong enough to yield ungrammaticality when a dependent indefinite lacks a licensor. This out-of-hand dismissal may be a touch too fast, though, in light of recent competition-based theories for syntactic distribution. For example, Spector 2014 argues that the French '*soit... soit...*' construction comes with obligatory exhaustification (i.e. enrichment by negating competing forms), and is licensed only if this exhaustification strengthens the meaning of the sentence.

Nevertheless, I will not be pursuing such an analysis here, for two reasons. First, theories of competition require a set of alternatives to compare to; the present case would require developing a theory of alternatives that allows not only lexical alternatives (e.g. *and* vs. *or*) to generate this set, but different scopal orderings. Perhaps more significantly, the competition-based view offers no extension to the case SAME and DIFFERENT whose truth conditions can't easily be stated in terms of competition with another form. Inspired by the morphological parallels in the ASL data, I view this as a theoretical priority.

In contrast, the mechanism developed here presents a clean way to capturing both the licensing facts and the similarity between dependent indefinites and SAME and DIFFERENT. However, because the current mechanism is built on a variation condition that is hard-wired into the semantics, we fail to predict the variation of individuals can disappear in certain cases, as above.

I'd like to suggest that we have already discovered a solution to this puzzle in our discussion about SAME: namely, the correct truth conditions can be modeled if we weaken the variation condition to hold of *events*, not *individuals*. Thus, the denotation of ONE-arc imposes the condition that there is a non-constant function from the licensor to a set of *events*, and entails that each of these events contains one individual in the relevant thematic role.[12] Additional pragmatic reasoning (perhaps through competition with the uninflected form) generates the implicature that the individuals vary as well.

This modification has a few interesting consequences, but none, I'll argue, that undermine the analysis built here. The most counterintuitive consequence is that our original generalization about dependent indefinites—namely, that dependent indefinites must scope below a universal quantifier—is no longer true in any form. Under the revised analysis, any distributive licensor, regardless of where it scopes, will introduce a plurality of events, so will satisfy the event-based variation condition. The reason for this arises from the condition of *thematic uniqueness* (also called the Unique Role Requirement; see Carlson 1984, Landman 2000, a.o.) which states that if two events have distinct theta roles, then they must be distinct events—for example, an event where John is the agent must be distinct from an event where Bill is the agent. What this means is that a distributive operator will *always* generate a plurality of events, because a unique event exists for each individual in the domain of the quantifier.

However, although this may be at odds with the way we originally stated the constraint, empirically, this is only allowing those truth conditions that we just established are in fact possible. More to the point, the analysis still derives the correct predictions in the places where it matters: we still successfully predict which DPs can act as licensors, and we still correctly rule out collective readings of plural licensors when relevant, as in (67), repeated below, which excludes readings on which the girls are interpreted collectively.

(98) ALL-a BOY-a GIVE ALL-b GIRL-b ONE-redup-b BOOK.
‘All the boys gave all the girls one book (per girl).’

For example, a singular NP still cannot license a dependent indefinite, as it will only introduce a single event (here, thematic uniqueness has no ill-effect). For exactly the same reason,

[12]By thematic uniqueness (Carlson 1984), this is a strict weakening, since $\theta(e) \neq \theta(e') \rightarrow e \neq e'$, so variation over individuals implies variation over events.

collective readings of plurals are ruled out; collective readings are exactly those where a plural NP collectively comprises a single thematic role of a single event. Finally, the same logic holds for NONE as held before: the sentence 'no student read a book,' yields no function from students to reading events, so a dependent indefinite is not licensed under NONE.

Because the technology that I will shortly develop is complicated enough on its own, the next chapter will return to a descriptive view where the variation of individuals is a semantic entailment. However, we have seen here that a pragmatic story can be introduced innocently by revising the condition to variation of events.

3.7 Summary

In this chapter, I addressed the empirical domain of functional reference and dependency, as it appears in a wide variety of phenomena in language. I showed that the properties of the sign language modality allow ASL to overtly represent dependent structures through the use of spatial association, thus allowing a more direct window into the mechanisms underlying these phenomena.

Empirically, we found compelling connections between dependent indefinites and SAME and DIFFERENT. Each of these nominal modifiers is able to move in space, agreeing with a plural or distributive licensor; this licensor serves as the input for a functional witness. For both ONE and SAME, the same licensing patterns were found: arc-movement requires a licensor; licensing is possible under plurals and universal quantifiers, but ungrammatical under singulars and NONE. We drew a connection between these licensing patterns and quantificational subordination in English.

Finally, we added a new piece of data regarding cases of multiple licensors, an empirical domain that has been shown to be of theoretical importance for the semantics of dependency. In ASL, because spatial agreement allows a dependent form to overtly specify its licensor, we showed that constructions that are ambiguous in spoken language can be disambiguated in ASL with the use of space.

Chapter 4

Dependency in Dynamic Plural Logic

4.1 Overview

In this chapter, I develop a formal analysis of dependency relations like the ones displayed by ONE-arc, TWO-arc, SAME-arc, and DIFFERENT-rep in ASL. The analysis will be developed within the framework of Dynamic Plural Logic (DPlL: van den Berg 1996, Nouwen 2003, Brasoveanu 2012, Henderson 2014), a form of dynamic semantics that represents dependencies between pluralities.

The plan of attack is as follows: I will begin by considering cross-linguistic patterns of dependent indefinites (like ONE-arc in ASL) in somewhat more depth. I will endorse the insight from recent analyses (Balusu 2006, Henderson 2014) that dependent indefinites check that a plurality has been introduced at a 'higher level' than their licensor. However, I will show that previous implementations face empirical challenges involving cumulative readings, arising from the need to posit a covert distributivity operator to license dependent indefinites in certain environments.

I will argue that a solution to this problem arises automatically when we build a system that is sufficiently powerful to capture the data from ASL. Specifically, as we have seen, ASL uses space to overtly relate a dependent term and its licensor; these examples thus require a system that formally represents this semantic link (for example, by Nouwen 2003's definition of dependency). As soon as we represent this anaphoric connection, though, we admit a degree of freedom that is not available to Henderson 2014; in this respect, the system becomes *less constrained* than his. But, it turns out that this extra degree of freedom allows us to simplify Henderson 2014's system in other ways, consequently freeing us from the problems associated with cumulative readings.

In §4.2, I present cross-linguistic data illustrating the empirical patterns of concern. In §4.3 and §4.4, I introduce Dynamic Plural Logic and provide comparison between existing implementations. In §4.5, I present a fragment and work through examples. In §4.6, I discuss the relation of the proposal to other analyses.

4.2 Licensing dependent indefinites

Natural language has a number of ways of morphologically marking dependency. When such inflection appears on an indefinite determiner or numeral, the resulting noun phrase is called a dependent indefinite (or dependent numeral)[1]. Broadly speaking, the word or suffix imposes the condition that the NP that it attaches to varies with respect to another NP in the sentence or in context.

For example, in Telugu, reduplication of a numeral creates a dependent indefinite (Balusu 2006): the sentence in (99) carries the meaning that the pairs of monkeys vary with respect to the boys. In English, Champollion 2015a argues that binominal *each* has a similar contribution: when *each* attaches to *two monkeys* in (100), it likewise contributes the meaning that the monkeys vary with the boys.

(99) **Telugu** (Balusu 2006)

a. pilla-lu renDu renDu kootu-lu-ni cuus-ee-ru.
kids 2 2 monkey-Pl-Acc see-Past-3PPL
'(The) kids saw <u>two monkeys each</u>.'

(100) **English**

a. The boys saw <u>two monkeys each</u>.

A key property of dependent indefinites regards the environments in which they are licensed. In many unrelated languages, dependent indefinites show the same licensing patterns: they are licensed under a plural or a distributive operator, but are ungrammatical when all other arguments are singular. This generalization holds of dependent indefinites in Kaqchikel (Henderson 2014), Hungarian (Farkas 1997), Romanian (Brasoveanu & Farkas 2011), Albanian (Rushiti 2015), in some dialects of English (Champollion 2015a), and in ASL (this work). In Telugu (Balusu 2006), the situation is slightly more complicated, since a dependent indefinite may indicate distribution of the NP over time or space (a 'temporal key' or 'spatial key' reading), in which case it needs no licensor. However, on the 'participant key' reading, in which the dependent indefinite indicates distribution of the NP with respect to another NP in the sentence (the only reading available in the other languages), Telugu reflects the same pattern as we see elsewhere: it is only possible with a plural or distributive licensor.[2]

The examples in (101)–(105) demonstrate this pattern with five unrelated languages. In each case, the same pattern holds: (a) and (b) are grammatical; (c), with no plural or distributive licensor, is ungrammatical (or, in the case of Telugu, ungrammatical on the relevant reading).

(101) **Kaqchikel Mayan** (Henderson 2014)

[1] The term 'distance distributivity' has been used to encompass a wider range of phenomena; additionally including participant-key readings of pluractionals (like French Sign Language /-alt/, discussed in Chapter 7), and perhaps even including internal readings of *same* and *different*.

[2] Russian *-nibud'* seems to be an exception to this generalization, being only licensed by an overt distributive operator (Yanovich 2005).

a. Xeqatij <u>ox-ox</u> wäy.
we-eat three-three tortilla
'We each ate three tortillas.'

b. Chikijujunal ri tijoxela' xkiq'etej <u>ju-jun</u> tz'i'.
each the students hugged one-one dog
'Each of the students hugged a dog.'

c. * Xe'inchäp <u>ox-ox</u> wäy.
I-handle three-three tortilla
Desired reading: 'I took (groups of) three tortillas.'

(102) **Telugu** (Balusu 2006)

a. pilla-lu <u>renDu-renDu</u> kootu-lu-ni cuus-ee-ru
kid-Pl two-two monkey-Pl-Acc see-Past-3PPl
'(The) kids saw two monkeys each.'
Two readings: 'participant key' and 'temporal key.'

b. Prati pillavaaDu <u>renDu-renDu</u> kootu-lu-ni cuus-ee-Du
Every kid two-two monkey-Pl-Acc see-Past-3PSg
'Every kid saw two monkeys (each).'
Two readings: 'participant key' and 'temporal key.'

c. Raamu <u>renDu-renDu</u> kootu-lu-ni cuus-ee-Du
Ram 2 2 monkey-Pl-Acc see-Past-3PSg
'Ram saw two monkeys each.'
Only 'temporal key' reading.

(103) **Albanian** (Rushiti 2015)

a. Fëmijët kanë parë <u>nga</u> pesë mace.
children-the have seen DIST five cats
'The children have seen five cats each'

b. Në çdo dhomë kishte <u>nga</u> dy fotografi.
in every room there-were DIST two photos
'There were two (different) photos in each room'

c. * Në dhomë kishte <u>nga</u> dy fotografi.
in room there-were DIST two photos
Desired reading: 'There were two (different) photos in the room.'

(104) **ASL**

a. BOYS IX-arc-a READ <u>ONE-arc-a</u> BOOK.
'The boys read one book each.'

b. EACH-EACH-a PROFESSOR NOMINATE <u>ONE-rep-a</u> STUDENT.
'Each professor nominated one student.'

c. * JOHN-a READ <u>ONE-arc-a</u> BOOK.
Desired reading: 'John read one book.'

(105) **English**

a. The boys saw two zebras each.

b. % Every job candidate was in the room for fifteen minutes each.[3]

c. * Ariella saw two zebras each.

What is compositionally challenging about this pattern is that quantifiers like *every* in English distribute down to atomic individuals, as evidenced by their ungrammaticality with collective predicates like *gather*, as in (106). The distributive operators discussed for other languages are parallel: (107) presents data from ASL; Henderson 2014 (f.n. 14) gives analogous data for Kaqchikel *chikijujunal*.

(106) **English**

a. The boys gathered.

b. * Every boy gathered.

c. * Edith gathered.

(107) **ASL**

a. MY FRIENDS, IX-arc-a GATHER.
'My friends gathered.'

b. * EACH STUDENT MY CLASS GATHER.
'Each student in my class gathered.'

c. * JOHN GATHER.
'John gathered.'

As discussed by a number of authors (e.g. Balusu 2006, Oh 2005), dependent indefinites under distributive operators seem to be puzzlingly redundant. That is, with a plural licensor, these morphemes seem to contribute distributive force themselves, but under distributive operators, they appear to be semantically vacuous. What, then, is the semantic contribution of the dependent indefinite? In particular, if there are certain cases in which they are semantically vacuous, then why can't they appear innocently under singular subjects?

Before sketching an answer to this puzzle, I'd like to observe to one final piece of data: namely, the adjective *same* shows the same distributional pattern as dependent indefinites, licensed by both plurals and distributive operators. See §6.2 of Barker 2007 for discussion of this puzzle.

(108) English *same* (on internal reading):

a. The students gave the same answer.

b. Each student gave the same answer.

[3]I use the symbol % to express a dialectal split regarding the judgment of this sentence. For more on the grammaticality of binominal *each* under distributive operators in English, see Szabolcsi 2010, Ch. 8, Bauman et al. 2012, and Champollion 2015a. For expositional purposes, I will henceforth discuss the dialect in which these are grammatical.

c. * Edith gave the same answer.

As discussed in Chapter 3, ONE-arc and SAME-arc are morphologically united in ASL. For now, I leave this here as one more suggestive piece of data pointing in the same direction. I will sketch a new analysis for the pattern in §4.5.4.

4.2.1 Checking plurality at different levels

In many respects, I will follow Henderson 2014's analysis of dependent indefinites. Two key pieces form the backbone of his proposal. First, the semantic contribution of a dependent indefinite is to check that an 'evaluation-level' plurality has been introduced. Second, some mechanism of scope-taking is available for this plurality condition to see outside of the scope of a distributive operator.

Brasoveanu 2008 observes that it is possible to distinguish different 'levels' of plurality in natural language. To illustrate this, consider the English sentences in (109). In both (109b) and (109c), we infer that a plurality of books were read, but there's a critical difference in where this plurality comes from. In (109b), there are multiple books from John's local perspective. In (109c), there is only one book from each boy's perspective, but, taken as a whole, the sentence can describe a global scenario involving multiple books.

(109) a. John read one book.
b. John read two books.
c. Every boy read one book. ($\forall > \exists$)
d. Every boy read two books. ($\forall > \exists$)

Brasoveanu 2008 calls a plural from a local perspective a **domain plurality**. A plural from a global perspective is an **evaluation plurality**. Somewhat more precisely, the difference between these two notions is the fact that an evaluation level plurality emerges from an interaction with another plurality in the sentence (in (109), the boys); often, but not always, this arises from an indefinite appearing in the scope of a distributive operator. An NP can introduce a domain plurality, an evaluation plurality, both, or neither; the table in (110) illustrates this with respect to the indefinites in the sentences in (109).

(110)

	eval. sing.	eval. plur.
dom. sing.	(109a)	(109c)
dom. plur.	(109b)	(109d)

Henderson 2014 argues that the semantic contribution of a dependent indefinite is to check for the presence of an evaluation plurality. For example, the Telugu dependent indefinite '*renDu-renDu kootuluni*' ('two-two monkeys') imposes the global constraint that there must be a plurality of pairs of monkeys. Of importance, because this definition is *checking* whether a property holds (as opposed to being an operator itself), the derivation may arrive at this representation in a variety of ways—not necessarily through a distributive operator.

Henderson 2014 argues that this is in fact exactly the correct prediction. Namely, dependent indefinites in Kaqchikel Mayan may be licensed either by a distributive operator (as by *chik-ijujunal*, above), or by a pluractional verbal form (marked by *-la'*). Based on the behavior of plain indefinites in both of these environments in Kaqchikel, Henderson shows that these two constructions have a fundamentally different compositional semantics.[4] Nevertheless, the two are united in the fact that they both, at the end of the day, introduce a plurality. This property provides the necessary conditions to license the presence of dependent indefinites.

(111) **Kaqchikel** (Henderson 2014)

a. Konojel xkikanöj **ju-jun** wuj.
   all search one-RED book
   'All of them looked for a book.'

b. Xinkan-ala' **ju-jun** wuj.
   search-ALA' one-RED book
   'I looked for a book (in each location or at each time).'

Finally, Henderson needs some mechanism to allow the plurality condition to see outside the scope of a distributive operator. For example, in (112), note that the indefinite *one book* necessarily scopes under *every boy*, but that the plurality condition imposed by *each* must be able to escape from the scope of *every boy* in order to make reference to global representation.

(112) Every boy read one book each.

Following Brasoveanu 2012, Henderson proposes that the plurality condition is a 'postsupposition'; essentially, this is a way in dynamic semantics to delay evaluation of the condition until the distributive scope has been closed off later in the computation. This strategy bears interesting connections to other strategies of delayed evaluation, including Bumford 2014's proposal that *each* and *every* compute dynamic iterated conjunction. Here, I will ultimately present an analysis using standard quantifier raising. I will return to the topic of postsuppositions in the exposition of Henderson's formal analysis in §4.4.4, and in comparison to my own proposal in §4.6.2.

4.3 Dependency in Dynamic Plural Logic

The analysis presented here will be implemented within Dynamic Plural Logic (DPlL: van den Berg 1996), a form of dynamic semantics that is designed to keep track of relationships between plural discourse referents. The system of DPlL has been developed and explored in a collection of recent work including van den Berg 1996, Nouwen 2003, Brasoveanu 2008, 2013, Henderson 2014, and Champollion 2015a. As I will discuss in this section, though, each of these formulations of DPlL is slightly different, notably differing in the dynamic contribution

[4] Essentially, unlike true distributive operators, pluractionals in Kaqchikel cannot make plain indefinites dependent. For the relevant paradigm and discussion, see Chapter 3, §3.6.1.

of an indefinite NP like *two boys*. The empirical domain where these differences become the most apparent is in the analysis of cumulative readings of plurals.

From the point of view of ASL, Dynamic Plural Logic presents an attractive formalism because it provides a way to dynamically build functional discourse referents through the semantic association of two plurals—in other words, exactly the kind of operation that seems to be visibly overt in the ASL paradigms discussed in Chapter 3. Moreover, thanks to the visibly overt representation of dependency, the ASL data give us insight into the choices between the various formulations of the theory. Two particular features of the ASL data stand out: first, we see an overt connection between a dependent term and its licensor; second, we see morphological unification of dependent indefinites with the adjectives *same* and *different*.

The plan for this section is as follows. I will begin by developing Dynamic Plural Logic, highlighting the choice-points in recent theories. With this as background, I will present Henderson's analysis for dependent indefinites. I will then turn to a challenge faced by his analysis generated by the need for a covert distributivity operator to license dependent indefinites under plurals. I will demonstrate that a solution to this puzzle can be found if we allow a dependent indefinite to include an anaphoric connection to its licensor (as in, e.g., Brasoveanu and Farkas 2011). I will argue that this anaphoric link is independently necessary to account for the data in ASL.

4.3.1 Brief background on cumulative readings

At various points in this chapter, I will be discussing **cumulative** readings of sentences with pural indefinites. In sentences with two plural indefinites, cumulative readings refer to the interpretation where neither indefinite is dependent on the other, and where each individual in the first plural is in the verbal relation with an individual in second plural, and vice versa.[5]

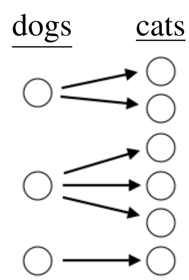
For example, the cumulative reading of (113) entails that three dogs licked cats in total and six cats were licked by dogs in total. The picture and table in (114) illustrate one scenario in which the cumulative reading of (113) is true.

(113) Three dogs licked six cats.

(114) a.

lickings	dogs	cats
e_1	d_1	c_1
e_2	d_1	c_2
e_3	d_2	c_3
e_4	d_2	c_4
e_5	d_2	c_5
e_6	d_3	c_6

b.



Given a basic verb meaning that denotes a relation between atomic individuals (e.g. atomic 'lickings'), the standard analysis of cumulative readings uses an operator that returns a predi-

[5]Cumulative readings are not to be confused with **collective** readings, in which one or both plurals are interpreted as acting as a group, collectively filling a thematic role of an atomic event.

cate's algebraic closure under sum formation (Link 1983). For two atomic individuals x and y, we use $x \oplus y$ to notate the sum of x and y. Following Krifka 1986, we define the sum of two tuples as in (115).

(115) $(x_1, ..., x_n) \oplus (y_1, ..., y_n) = (x_1 \oplus y_1, ..., x_n \oplus y_n)$

The algebraic closure of a relation R is then given by the 'star'-operator, defined in (116). Here, $\vec{x}$ and $\vec{y}$ are tuples of individuals.

(116) **Algebraic closure of a relation** (Krifka 1986, based on Link 1983)
$^*R$ is the smallest set R' such that $R \subseteq R'$ and $\forall \vec{x}, \vec{y} \in R'[\vec{x} \oplus \vec{y} \in R']\}$

For example, if Fido licked Fluffy and Rex licked Crookshanks, then (Fido $\oplus$ Rex) *licked (Fluffy $\oplus$ Crookshanks).

4.3.2 Background: Dynamic plural logic

In dynamic semantics, sentence meanings are modeled as functions that change the context in some way; most notably, they can add new discourse referents into the context. In standard dynamic semantics (Groenendijk & Stokhof 1991, Dekker 1993), active discourse referents are formally represented as the values of an assignment function—essentially, a list of individuals—that is passed from sentence to sentence through the discourse. The output context of one sentence serves as the input context of the next sentence. Certain operators, including indefinites, can add new individuals to the end of this list. Pronouns retrieve elements from the list.

For example, in (117), both indefinites ('a boy' and 'a girl') introduce a new individual to the list of discourse referents. Evaluating the first sentence yields the set of all the possible outputs that are compatible with the sentence. These outputs then serves as the possible inputs for the second sentence, which updates the context again. Figure 4.1 shows the effect of updating a neutral context with each of the sentences in (117). (The pronoun retrieves the value of y.)

(117) (a) A_x boy entered. (b) A_y girl exited. (c) She_y was angry.

Within a dynamic system, particular operators may themselves be dynamic or static, based on their contribution to the sentence: dynamic operators change the context; static operations only test to see if certain conditions are met. For example, the sentence '*A girl exited*' is dynamic, because it adds a new individual into the discourse that can be referred to later. This can be seen in the assignment of a new variable in the transition in Figure 4.1b. In contrast, the sentence '*She was angry*' is static; it merely filters the input contexts by imposing the condition that the value of some previously defined variable has a certain property. Assuming that Alicia was angry but Mary was not, the result is the transition in Figure 4.1c, which returns a subset of its input contexts.

In standard dynamic semantics, distributive quantifiers like *every* and *each* are taken to be 'externally static,' collapsing all new variables that are introduced in their scope, making them

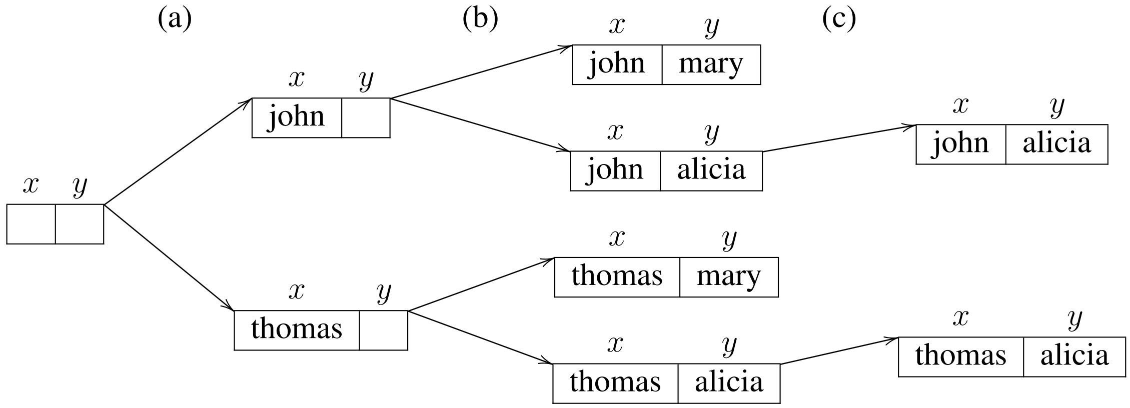


Figure 4.1: Dynamic updates of the sentences in (117)

unavailable for later sentences. At a first approximation, this seems to be a correct generalization: as seen in (118), an indefinite in the scope of a universal can't serve as the antecedent for an individual pronoun.

(118) * Every$_x$ farmer owns a$_y$ donkey. It$_y$ kicked me in the shin.

The difference between an indefinite (which can change the context) and a universal (which can't) is clear in their definitions in Dynamic Predicate Logic (Groenendijk & Stokhof 1991). In particular, the fact that the universal is externally static can be seen in its requirement that '$h = g$' in (119b), that is, that the output context of the sentence as a whole is the same as its input context.

(119) $\exists$ and $\forall$ in Dynamic Predicate Logic (Groenendijk & Stokhof 1991)

a. $[\![\exists x\varphi]\!] = \{\langle g,h\rangle | \exists k : k[x]g \ \wedge \ \langle k,h\rangle \in [\varphi]\}$

b. $[\![\forall x\varphi]\!] = \{\langle g,h\rangle | h = g \ \wedge \ \forall k : k[x]h \rightarrow \exists j : \langle k,j\rangle \in [\varphi]\}$

To see how the definition in $\forall x\varphi$ works, consider the first sentence of (118). The truth conditions are arrived at by considering the set of assignment functions where x is assigned to a farmer. If each assignment function considered satisfies the test that x owns a donkey (in the process, adding a donkey as the value for y), then the original input assignment is passed along as an output context (without the added values for x and y). If any assignment function fails the test, it is not.

It turns out, however, that it *is* possible to anaphorically access a variable introduced in the scope of a distributive quantifier—but only in certain environments. These cases of 'quantificational subordination' (terminology from Heim 1990, Brasoveanu 2006) require a very particular configuration: in the antecedent sentence, an indefinite scopes below a distributive quantifier; in the subsequent sentence, a pronoun scopes below an operator that quantifies over the same set as the original distributive quantifier. Sentence (120) provides an example.

(120) Two$_x$ farmers each own a$_y$ donkey. Neither of them$_x$ treat it$_y$ very well.

Observe, in (120), that the prounoun *it* is anaphoric to the indefinite *a donkey*, yet it refers neither to a single particular donkey nor to the set of all donkeys; rather, it varies with respect to the farmer in question. Moreover, this is not some arbitrary new correspondence between farmers and donkeys; it must be the same correspondence that was introduced by the first sentence. The sentences entail that *whichever* donkey is owned by a farmer, *that* is the donkey that he doesn't treat well.

As we have just seen, in standard dynamic semantics, the evaluation of a universal quantifier tests each of a set of assignments; if these are satisfied, it closes the scope of the universal, and discards the assignments it built along the way. Essentially what the example in (120) shows is that we need to be able to 're-open' the scope of a universal, to see what the value of y was for each value of x in the intermediate computation. In other words, we need to store all the assignment functions that were used in the evaluation of a universal quantifier.

Dynamic Plural Logic is an enrichment of dynamic semantics that does exactly this: instead of passing assignment functions through the discourse, it passes *sets* of assignment functions. This allows dependency relationships to be formally represented and stored. As before, the evaluation of a universal quantifier tests each of a set of assignments; in DPlL, if these are satisfied, it collects them and adds the entire set to the discourse context. Figure 4.2 shows the effect of updating a neutral context with each of the sentences in (120) in DPlL.

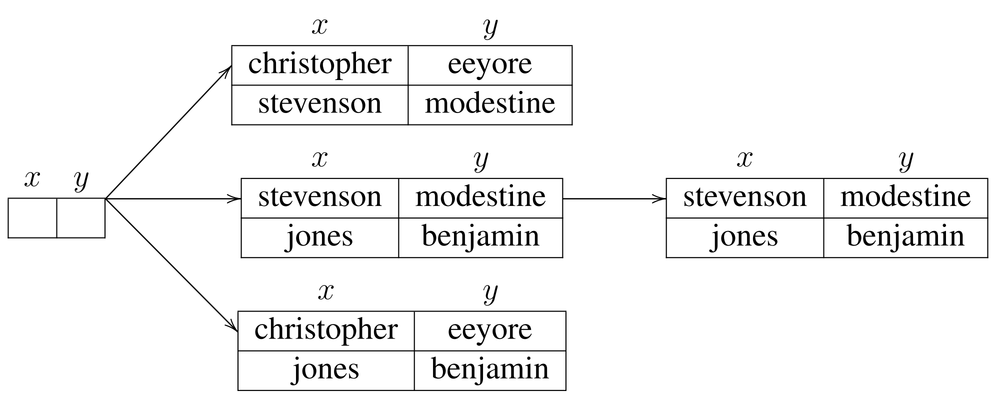


Figure 4.2: Dynamic updates of the sentences in (120) in Dynamic Plural Logic

We will call these sets of assignment functions 'information states.' One should note that these representations look essentially identical to the tables that we built in Chapter 3 to describe particular verifying scenarios for certain sentences. The representations built here should be thought of in exactly the same way: these are the contexts which verify the sentence that generated them.

4.3.3 Formally defining information states (and dependency)

We use g and h as variables over assignment functions (essentially, lists of individuals). We use G and H as variables over sets of assignment functions ('information states,' essentially, tables of individuals). Undefined cells in an information state will be notated as having value '$\star$'. We will treat partial assignment functions as total assignment functions on which most values are undefined. So, the table shown in (121a) is really shorthand for the table in (121b).

(121) a.

	x	y
g_1 :	a	c
g_2 :	b	d

b.

	x	y	z	
g_1 :	a	c	$\star$	...
g_2 :	b	d	$\star$	

The following definitions provide a way to refer to subparts of these tables.

(122) **Definition:** $G(x)$
$G(x) := \{g(x) | g \in G \ \& \ g(x) \neq \star\}$
'the set of defined values in the x-column of a table'
(roughly: 'a vertical slice')

(123) **Definition:** $G|_{x=d}$
$G|_{x=d} := \{g | g \in G \ \& \ g(x) = d\}$
'the rows of a table where x is assigned to d'
(roughly: 'a thick horizontal slice')

For example, if G is the table in (124a), then (124b) provides $G(y)$ and (124c) provides $G|_{x=\text{a}}$.

(124) a. $G =$

x	y
a	c
a	d
b	d
e	$\star$

b. $G(y) = \{c, d\}$

c. $G|_{x=\text{a}} =$

x	y
a	c
a	d

Using these definitions, we can now introduce a formal definition of dependency.

(125) In an information state G, y is dependent on x iff
$\exists d, e \in G(x).G|_{x=d}(y) \neq G|_{x=e}(y)$ Nouwen 2003, page 84

That is, we compare the set of values assigned to y for each subtable in which x is assigned to a different value. If there is variation in these sets, then there is a dependency between y and x. Looking at (126), for example, in G_1, y does not depend on x, since the two sets being compared are the same; in G_2, y does depend on x, since these two sets are different.

(126) $G_1 =$

x	y	
a	c	$G\|_{x=\text{a}}(y) = \{\text{c}, \text{d}\}$
a	d	
b	c	$G\|_{x=\text{b}}(y) = \{\text{c}, \text{d}\}$
b	d	

$G_2 =$

x	y	
a	c	$G\|_{x=\text{a}}(y) = \{\text{c}, \text{d}\}$
a	d	
b	c	$G\|_{x=\text{b}}(y) = \{\text{c}, \text{e}\}$
b	e	

4.3.4 Making it dynamic

Having developed a way to talk about the static properties of these representations, we now move to the dynamic components of the model. The basic operation underlying dynamic change is **assignment modification**, which allows us to add a new discourse referent into a context.

(127) **Definition:** $g[x]h$ iff for any variable v, if $v \neq x$, then $g(v) = h(v)$

For two assignment functions g, h, if $g[x]h$, then h is identical to g except at x. For example, (128) provides possible values for g and h if $g[y]h$ is true.

(128) Possible values for g, h if $g[y]h$:

a. $g =$

w	x	y	z	
a	b	$\star$	$\star$	$\cdots$

b. $h =$

w	x	y	z	
a	b	c	$\star$	$\cdots$

At this point, the question is: what should the analogous operation be in Dynamic Plural Logic? Are plurals entered in a single cell (as a sum individual) or across multiple cells? Can the introduction of a plural generate dependencies?

It turns out that the answers to these questions are one of the largest places of variation within the small literature within Dynamic Plural Logic. Several significant contributions to the framework of Dynamic Plural Logic include van den Berg (1996), Nouwen (2003), Brasoveanu (2013), and Henderson (2014). In the next section, I will provide an overview of these systems before introducing my own (highlighting which parts are adopted and which parts are new).

4.4 Overview of systems

In this section, I will overview existing variants of Dynamic Plural Logic. Similar to DRT, in these variants of DPlL, interpretation is conducted via an intermediate stage of representation: natural language is systematically translated into a logical form that is then interpreted. Thus, throughout §4.4, the interpretation brackets $[\![\cdot]\!]$ will appear around expressions in this intermediate logic. I will indicate translation of natural language expressions into this logic using English prose: "X is translated as Y."

For matters of preference, my own analysis in §4.5 will dispense with the intermediate level of representation; instead, natural language expressions will be directly interpreted. No great theoretical weight hangs up on this decision, but the shift will require a subtle change in notation: interpretation brackets will map natural language expressions directly to meanings. Notation will be reviewed again at the beginning of §4.5.

Van den Berg 1996 and Nouwen 2003 provide a trivalent semantics for DPlL, defining conditions for truth, falsity, and undefinedness. Since this does not play a critical role in my discussion here, I will follow Brasoveanu 2012 and Henderson 2014 in defining only the conditions for truth for a given proposition in DPlL. (Notationally, I will write $[\![\varphi]\!]^{\langle G,H\rangle} = \mathbb{T}$ iff

....) The interested reader is referred to Nouwen 2003 for more discussion of undefinedness in DPlL.

One further note should be mentioned regarding notation: I will be providing a definition for conjunction that allows information to pass asymmetrically through the discourse; to avoid overloading notation, '$\wedge$' will be used for dynamic conjunction; '$\&$' will be used for classical boolean conjunction.

4.4.1 Van den Berg and Nouwen's DPlL

In the DPlL of van den Berg 1996 and Nouwen 2003, a plurality is introduced into an information state G by adding each member of the plurality into G once for each row already in G. Thus, the output state generated by updating G with a given plurality has cardinality equal to the cardinality of G multiplied by the cardinality of the plurality.

(129) **Definition (vdB + N)[6]:** $[x]$
$G[x]H \quad \Leftrightarrow \quad G(x) = \emptyset \quad \& \quad \exists X.H = \{h \mid \exists g \exists d.g[x]h \;\&\; h(x) = d \;\&\; g \in G \;\&\; d \in X\}$

For example, if an input state G contains three rows, as in (131a), then updating G with a plurality of two individuals will produce an information state with six rows, as in (131b).

(131) $G[z]H$

a. $G =$

x	y	z
a	d	$\star$
b	d	$\star$
c	e	$\star$

b. $H =$

x	y	z
a	d	f
a	d	g
b	d	f
b	d	g
c	e	f
c	e	g

Note that the operation of variable introduction preserves all dependencies that exist in the input state (above, y depends on x in both G and H), but by definition does not introduce any new dependencies (in H, z depends on neither x nor y).

We define $[x]$ to be variable introduction relativized to an input and output state, as in (132).

(132) $[\![[x]]\!]^{\langle G,H \rangle} = \mathbb{T} \quad \text{iff} \quad G[x]H$

A dynamic predicate P is a test that ensures that a certain property holds between the values of n variables. In van den Berg and Nouwen's DPlL, an interpretation function I associates a given dynamic predicate P with a relation on sets of individuals that characterizes the meaning

[6] This is a notational variant of the definition given in van den Berg 1996 and Nouwen 2003: they define $g[x/d]$ to be the assignment function h such that $g[x]h$ and $h(x) = d$. Their definition for the existential is as follows:

(130) $G[x]H \quad \Leftrightarrow \quad G(x) = \emptyset \quad \& \quad \exists X.H = \{g[x/d] | g \in G \;\&\; d \in X\}$

of the predicate; the n-ary dynamic predicate P collapses the plurals in each of n variable slots into sets, and tests that the relation $I(P)$ holds of these sets. Following convention in recent works, I use SMALL CAPS to indicate the meaning of a predicate in DPlL.

(133) **Definition (vdB + N):** P
$[\![Px_1, ..., x_n]\!]^{\langle G,H\rangle} = \mathbb{T}$ iff $G = H$ & $\langle G(x_1), ..., G(x_n)\rangle \in I(P)$

For example, the relation on sets $I(\text{INVITED})$ is the set of 2-tuples $\langle S, T\rangle$ such that S invited T. The dynamic proposition INVITED(x, y) would hold of the representation in (131b) if $\langle\{\text{a}, \text{b}, \text{c}\}, \{\text{d}, \text{e}\}\rangle \in I(\text{INVITED})$—that is, if a, b, and c invited d and e. Because this definition of P discards the internal structure of the information state, the default interpretation of a sentence is collective.

A test is a static operation that doesn't add any new values to the input information state; instead, it acts as a filter, imposing more conditions on the values currently residing in the state. For example, if G_1, G_2, and G_3 are all possible output states from the previous discourse, after INVITED(x, y) is evaluated, the only possible output states will be the subset in which the individuals in x invited the individuals in y, perhaps only G_2 and G_3.

Conjunction is interpreted dynamically, as defined in (134), so that operators in the right conjunct have access to discourse referents introduced in the left conjunct, but not vice versa.

(134) $[\![\varphi \wedge \psi]\!]^{\langle G,H\rangle} = \mathbb{T}$ iff $\exists K.[\![\varphi]\!]^{\langle G,K\rangle}$ & $[\![\psi]\!]^{\langle K,H\rangle}$

The logical form in (135) provides an example in which $[x]$ is conjoined with the predicate GIRLS(x). Figure 4.3 illustrates these operations graphically. In Figure 4.3 (and subsequent figures), a double-right arrow ($\Rightarrow$) represents the dynamic contribution of a given proposition; the proposition in question is indicated as a superscript above the arrow. As we have seen, a proposition φ defines a two-place relation on information states. In the figure below, each arrow relates a *set* of input states to a *set* of output states: the set of states to the right of an arrow '$\overset{\varphi}{\Longrightarrow}$' are the complete set of states H that have a state G to the left of the arrow such that $[\![\varphi]\!]^{\langle G,H\rangle}$. Dynamic conjunction entails that some information state ('K') is the output state of the left conjunct and the input state of the right conjunct; as a result, we can illustrate conjunction as a sequence of sets of states connected by arrows.

We model a 'neutral context' as a singleton set containing an empty information state. Figure 4.3 illustrates (135) evaluated in a neutral context: first, a plurality is introduced across the variable x; then the predicate GIRLS(x) filters out the information states in which x does not consist of girls. (Note that the figures below only show a partial representation, since a proposition may generate a potentially infinite number of output states.)

(135) $[x] \wedge$ GIRLS(x)

Dependencies can be introduced into a representation with a distributive operator, as defined in (136). As we saw in §4.3.2, in natural language, existential expressions in the scope of a distributive operator are able to introduce new discourse referents into the context—relevant examples included discourses like '*Two farmers each own a donkey. Neither of them treat it*

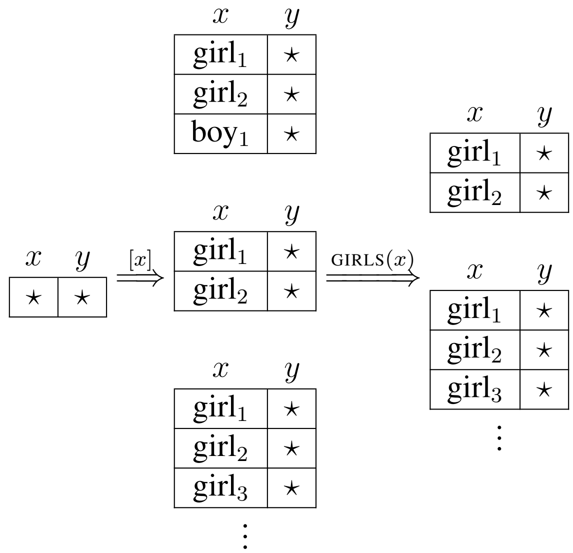


Figure 4.3: Partial representation of dynamic updates of (135)

very well.' Nevertheless, there must be some constraints that prevent the information state from changing in pathological ways. In (136a), the condition that $G(x) = H(x)$ ensures that the values of the variable being distributed over—x—remain constant from the input to the output (this is not to be confused with the condition elsewhere that $G = H$, which requires full identity of G and H). The condition that $G|_{x=\star} = H|_{x=\star}$ ensures that no values are modified in any assignment function g where $g(x)$ is undefined.

The meat of the definition—the dynamic component—appears in (136b). Given an input-ouput pair $\langle G, H\rangle$, $\delta_x(\varphi)$ considers the substates of G and H with x restricted to each value d. For each of these pairs of substates, the clause in (136b) states that the output substate can be attained from the input substate via the evaluation of φ. If the evaluation of φ introduces a new discourse referent into the context, this means that a discourse referent is introduced in H for each value of x.

(136) **Definition:** δ_x

$[\![\delta_x(\varphi)]\!]^{\langle G,H\rangle} = \mathbb{T}$ iff

a. $G(x) = H(x) \ \wedge\ G|_{x=\star} = H|_{x=\star} \wedge$

b. $\forall d \in G(x).[\![\varphi]\!]^{\langle G|_{x=d}, H|_{x=d}\rangle}$

Procedurally, because the sub-computations of $[\![\varphi]\!]^{\langle G|_{x=d}, H|_{x=d}\rangle}$ are independent from each other, the evaluation of δ_x can be thought of as a process of dividing up G with respect to the values of x, evaluating φ on each of these substates in parallel, then gathering up the resulting states.

The logical form in (137) provides an example to illustrate this procedural metaphor. As seen in Figure 4.4, δ_x splits the computation along the x variable, adds one book that was read by x as a value for y, then merges the computation together again.

(137) $\delta_x([y] \wedge \textsc{book}(y) \wedge \textsc{read}(y, x))$

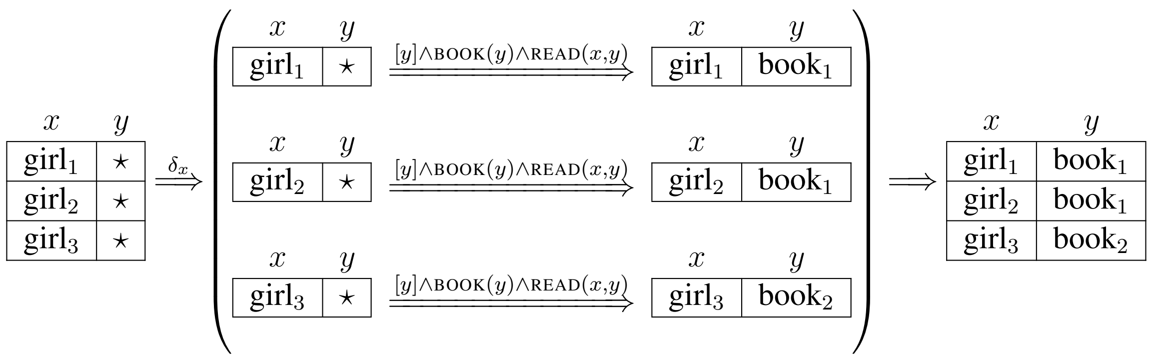


Figure 4.4: Partial representation of dynamic updates in (137)

To give a concrete example, we will assume (138b) to be the logical translation of the natural language sentence in (138a); here, *some* is associated with the logical expression $[x]$, *each* is associated with the expression δ_x, and *a* is associated with $[y]$. Because (138b) is the conjunction of (135) and (137), a graphical representation for (138b) can be created by composing Figure 4.3 with Figure 4.4. Figure 4.5 shows the results of this composition.

(138) a. Some girls each read a book.

b. $[x] \wedge \textsc{girls}(x) \wedge \delta_x([y] \wedge \textsc{book}(y) \wedge \textsc{read}(x, y))$

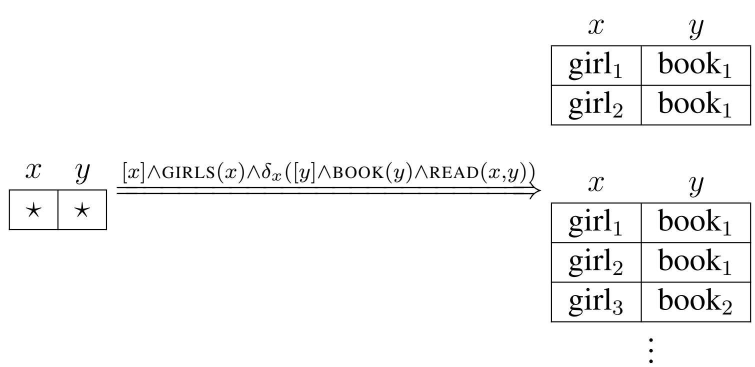


Figure 4.5: Partial representation of the dynamic updates of (138)

Of note, observe that the output states in Figure 4.5 now have a dependency in the formal sense defined in (125): the values of y depend on the values of x.

In anticipation of revisions that I will adopt in the following sections, I want to highlight one domain where the current formulation provides no clear analysis: namely, cumulative readings. When two plural indefinites are independent from each other in a sentence (i.e., when there is no intervening δ operator), the only way to interpret their relation is collectively.

One potential avenue to capture cumulative readings is to import a standard analysis, and to apply a closure operator to P to make ${}^*P$. This solution produces the correct truth conditions for cumulative readings, but with the counterintuitive result that the representation ends up containing many superfluous rows. For example, if Alexis hugged Anton, and Isabelle hugged Mark (and no other huggings occurred), the only information state that would verify the sentence '*The girls hugged the boys*' is the one in (139), containing more rows than hugs.

(139)

x	y
Alexis	Anton
Alexis	Mark
Isabelle	Anton
Isabelle	Mark

On a more empirical level, the present implementation faces challenges when we attempt to extend it to account for dependent indefinites. On most semantic analyses (e.g., Farkas 1997, Brasoveanu & Farkas 2011), a dependent indefinite imposes the constraint that the DP it introduces varies with respect to another DP in the sentence. As we have seen, the framework is DPlL is well equipped to formalize this insight with the definition of dependency presented in (125).

However, as shown above, in van den Berg/Nouwen's system, the only way to introduce a dependency is with δ_x; the licensing of dependent indefinites thus becomes contingent on the presence of an overt or covert distributivity operator. In Chapter 3 §3.6.1, I argued that this gets the wrong prediction on a number of fronts: it can't account for licensing by pluractionals in Kaqchikel (Henderson 2014), it can't account for cases where a dependent indefinite is conjoined with a plain indefinite that is interpreted collectively or cumulatively (such as in Hungarian and Tamil), and it can't account for the morphological similarity between dependent indefinites and SAME in ASL.

In the following section, I describe revisions to this theory by Brasoveanu 2012 (adopted by Henderson 2014). On the new proposal, cumulative readings are the default interpretation of plural predication, and the definition of $[x]$ is revised so that two plural indefinites may introduce a dependency without a distributive operator.

4.4.2 Brasoveanu and Henderson's DPlL

In the DPlL of Brasoveanu 2012 and Henderson 2014, a plural is introduced into an information state by distributing the atoms of the plural across the cells of the column of a new variable, keeping all other assignments the same.

(140) **Definition (B+H):**

$G[x]H = \mathbb{T}$ iff for all $g \in G$, there is a $h \in H$ such that $g[x]h$, and
for all $h \in H$, there is a $g \in G$ such that $g[x]h$

Let us see how this works with the G and H in (141). To check that $G[y]H$, we first check that for each g there is an h such that $g[y]h$; this holds: $g_1[y]h_1$ and $g_2[y]h_2$. Conversely, we check that for each h there is an g such that $g[y]h$; this also holds: $g_1[y]h_1$, $g_2[y]h_2$, and $g_2[y]h_3$. Therefore, $G[y]H$ holds of this input and output state.

(141) a. $G =$

	x	y
g_1	a	$\star$
g_2	b	$\star$

b. $H =$

	x	y
h_1	a	c
h_2	b	d
h_3	b	e

One thing of note that this example illustrates is that G and H may differ in cardinality, since some $g \in G$ may correspond to multiple $h_1, ..., h_n \in H$, provided that $h_1, ..., h_n$ differ only with respect to the newly assigned variable.

A dynamic predicate P is a test that ensures that a certain property holds between the values of n variables on each assignment function in an information state. The interpretation function I is redefined: for a given predicate P, $I(P)$ is a relation on individuals (not sets of individuals). For a given input state G, the n-ary dynamic predicate P checks that $I(P)$ holds of the values of a certain n variables for each $g \in G$.

(142) **Definition (B+H)[7]:** P
$$[\![Px_1, ..., x_n]\!]^{\langle G,H \rangle} = \mathbb{T} \quad \text{iff} \quad G = H \;\wedge\; \forall g \in G.\langle g(x_1), ..., g(x_n)\rangle \in I(P)$$

For example, the classical relation $I(\text{INVITED})$ is the set of 2-tuples $\langle x, y\rangle$ such that x invited y. The dynamic proposition $\text{INVITED}(x, y)$ would hold of the representation in (141b) if $I(\text{INVITED})$ contains $\langle \text{a}, \text{c}\rangle$, $\langle \text{b}, \text{d}\rangle$, and $\langle \text{b}, \text{e}\rangle$—that is, if a invited d, b invited d, and b invited e. Note that this preserves the internal structure of the information state, and captures cumulative readings automatically without the need for ${}^*P$.

Cardinality measures are also tests. Brasoveanu defines the dynamic proposition $x = n$ as in (143). For an input information state G and an integer n, $x = n$ is tests that there are exactly n distinct values of $g(x)$ for $g \in G$.

(143) $[\![x = n]\!]^{\langle G,H \rangle} = \mathbb{T} \quad \text{iff} \quad G = H \;\wedge\; |H(x)| = n$

For example, in (141b), $|H(x)| = 2$ and $|H(y)| = 3$.

The following example illustrates the behavior of variable introduction and predication in Brasoveanu 2012's system with a simple sentence. The logical translation of (144a) is provided in (144b), and is illustrated in (145). Since conjunction is interpreted dynamically, the logical form in (144b) is read from left to right. First, $[x]$ introduces some plurality of individuals for the variable x, with no restrictions on their value. The resulting set of output states are filtered to only include those where the cells of x are girls, then filtered again so that there are only two values in the cells of x.

In the next block, $[y]$ introduces the variable y; observe that either column in the x or y can have duplicate values, as we observed in (141). The two tests then filter the y column to only include dogs, then to have only three values. Finally, the relation SAW filters out only those information states in which each value of x saw the value of y in the same row.

A sentence is evaluated as true with respect to a given input context if there are any output contexts after evaluation of the sentence.

(144) a. Two$_x$ girls saw three$_y$ dogs.

b. $[x] \ \wedge \ \textsc{girls}(x) \ \wedge \ x = 2 \ \wedge \ [y] \ \wedge \ \textsc{dogs}(y) \ \wedge \ y = 3 \ \wedge \ \textsc{saw}(x, y)$

(145)

x	y
⋆	⋆

$\xRightarrow{[x]}$

x	y
girl$_1$	⋆
girl$_2$	⋆
boy$_1$	⋆

x	y
girl$_1$	⋆
girl$_2$	⋆

x	y
girl$_2$	⋆
girl$_3$	⋆

x	y
girl$_1$	⋆
girl$_2$	⋆
girl$_3$	⋆

$\xRightarrow{\textsc{girls}(x)}$

x	y
girl$_1$	⋆
girl$_2$	⋆

x	y
girl$_2$	⋆
girl$_3$	⋆

x	y
girl$_1$	⋆
girl$_2$	⋆
girl$_3$	⋆

$\xRightarrow{x=2}$

x	y
girl$_1$	⋆
girl$_2$	⋆

x	y
girl$_2$	⋆
girl$_3$	⋆

$\Rightarrow \cdots$

$\cdots \xRightarrow{[y]}$

x	y
girl$_1$	boy$_1$
girl$_2$	dog$_2$
girl$_2$	book$_1$

x	y
girl$_1$	dog$_2$
girl$_1$	dog$_3$
girl$_2$	dog$_1$

x	y
girl$_2$	dog$_1$
girl$_3$	dog$_2$

x	y
girl$_2$	dog$_1$
girl$_2$	dog$_3$
girl$_3$	dog$_2$
girl$_3$	dog$_3$

$\xRightarrow{\textsc{dogs}(y)}$

x	y
girl$_1$	dog$_2$
girl$_1$	dog$_3$
girl$_2$	dog$_1$

x	y
girl$_2$	dog$_1$
girl$_3$	dog$_2$

x	y
girl$_2$	dog$_1$
girl$_2$	dog$_3$
girl$_3$	dog$_2$
girl$_3$	dog$_3$

$\xRightarrow{y=3}$

x	y
girl$_1$	dog$_2$
girl$_1$	dog$_3$
girl$_2$	dog$_1$

x	y
girl$_2$	dog$_1$
girl$_2$	dog$_3$
girl$_3$	dog$_2$
girl$_3$	dog$_3$

$\Rightarrow \cdots$

	x	y
	$girl_1$	dog_2
	$girl_1$	dog_3
	$girl_2$	dog_1

$\ldots \xRightarrow{\text{SAW}(x,y)}$

x	y
$girl_2$	dog_1
$girl_2$	dog_3
$girl_3$	dog_2
$girl_3$	dog_3

4.4.3 Two ways to cumulate for Henderson 2014

Henderson 2014 adopts Brasoveanu's definition for the existential, but in fact doesn't (exclusively) use this strategy to get cumulative readings.

Henderson 2014's primary domain of concern is dependent indefinites; as discussed in §4.2.1, his analysis is motivated by the insight that dependent indefinites introduce an 'evaluation level' plurality—that is, a level of plurality that emerges only by interaction with other plural arguments. On the other hand, Henderson also takes it as a theoretical desideratum that a dependent indefinite should be able to check for an evaluation cardinality without explicit reference to its licensor (contra, e.g., Brasoveanu and Farkas 2011, who posit an anaphoric component). In other words, the goal is a system in which we can tell what kind of plural a variable x is just by looking at $G(x)$ in isolation. For instance, comparing the sentences '*John read three*$_y$ *books*' and '*Three boys read one*$_y$ *book each*,' we want to be able to look at $G(y)$ and be able to determine that the variable y in the former sentence is a domain-level plural and in the latter is an evaluation-level plural.

Henderson's solution is to posit two different kinds of structures for pluralities. As in Brasoveanu 2012, there are pluralities whose subparts are distributed across multiple $g_1, ..., g_n$ in G. Additionally, Henderson (re)introduces sum-individuals $x \oplus ... \oplus y$ that reside within a single g. Domain level plurals are pluralities that exist within a single cell; evaluation pluralities are distributed across several cells. For example, under Henderson's analysis, the English sentence in (146) would generate the representation in (147). Here, the value of $G(y)$ is {d ⊕ e, f ⊕ g, h ⊕ i}, from which it can be read off that there is both a domain plurality (because there are non-atomic sum-individuals) and an evaluation plurality (because there are more than one of them).

(146) Every boy saw two girls.

(147) $G =$

x	y
a	d ⊕ e
b	f ⊕ g
c	h ⊕ i

However, a cost of this architectural decision is that Henderson is again forced to use ${}^*P$ for the cumulative readings of the domain-level plurals; this means that the system has two completely different ways to get cumulative readings. As we will see in the next section, this decision is in part responsible for a puzzle that arises with plural licensors.

4.4.4 Henderson 2014 on dependent indefinites

Henderson's proposal is the following. The general architecture and definition of variable introduction ($[x]$) are the same as Brasoveanu 2012's. Unlike Brasoveanu 2012, though, plain numerals are defined as checking the cardinality of a sum individual. The numeral *two*$_x$ checks that every cell of $G(x)$ contains a sum individual with two atomic parts, as defined in (148) and (149).

(148) $[\![\mathbf{two}(x)]\!]^{\langle G,H\rangle} = \mathbb{T}$ iff $G = H \;\wedge\; \forall h \in H.|\{x'|\mathbf{atom}(x') \;\wedge\; x' \preceq h(x)\}| = 2$

(149) 'two$_x$' is translated as $[x] \;\wedge\; \mathbf{two}(x)$

Thus, the outputs in (150a) and (150b) satisfy the quantitative condition imposed by *two*$_x$; the one in (150c) does not.

(150) a.

x
boy$_1\oplus$ boy$_2$

b.

x
boy$_1\oplus$ boy$_2$
boy$_1\oplus$ boy$_3$

c.

x
boy$_1\oplus$ boy$_2$
boy$_1\oplus$boy$_2\oplus$ boy$_3$

Dependent indefinites have exactly the same definition, but with an added condition: there must be an evaluation-level plurality, as defined in (151) and (152). (Here, I use the pseudo-English *two-two* as stand-in for the appropriate dependent indefinite in a given language.)

(151) $[\![x > 1]\!]^{\langle G,H\rangle} = \mathbb{T}$ iff $G = H \;\wedge\; |H(x)| > 1$

(152) 'two-two$_x$' is translated as $[x] \;\wedge\; \mathbf{two}(x) \;\wedge\; x > 1$

Thus, only the output in (150b) satisfies the two quantitative conditions imposed by *two-two*$_x$.

The next concern of Henderson 2014's analysis is to distinguish between singular and pluractional verbs. As described in §3.6.1, Kaqchikel has a verbal suffix *-la'* that indicates that multiple events occurred. We have also seen that pluractional verbs license dependent indefinites in Kaqchikel; singular verbs (by themselves) do not. Semantically, then, what is the difference between the two?

From a certain point of view, the fundamental question here is not why pluractional verbs *can* license dependent indefinites, but rather, why singular verbs *cannot*. In particular, the operation $[x]$ is defined so that it can freely distribute individuals across multiple assignment functions, and the definition of a dependent indefinite, as given in (152), does nothing to rule this out. Thus, Henderson needs some way to ensure that indefinites don't end up introducing evaluation cardinalities in sentences with singular verbs and singular arguments.

The solution that Henderson 2014 provides is to say that verbs impose the condition that they introduce an evaluation singular on the event variable ('$e = 1$' below). Example (153) provides the translation of the singular verb *dance*.

(153) ‘dance’ is translated as $[e] \ \wedge \ e = 1 \ \wedge \ \text{DANCE}(e)$

The fact that the event variable must be an evaluation singular means that the thematically related individual variable must also be an evaluation singular. The reason for this arises from the assumption of *thematic uniqueness* (see Chapter 3, §3.6.2), which posits that a single event cannot have two distinct theta roles.

Consider, for example, the ungrammatical Kaqchikel sentence in (154), with a translation in (155). Here, the verb imposes the condition that the event variable is an evaluation singular (‘$e = 1$’). The event variable is thematically related to the variable of the dependent indefinite (‘TH(e,x)’); by thematic uniqueness, x must therefore also be an evaluation singular. However, this contradicts the constraint from the dependent indefinite that x is an evaluation plurality (‘$x > 1$’), and the sentence is ruled out.

(154) * Xe’inq’etej ox-ox ak’wala’.
I-hug three-three children

(155) $[x] \ \wedge \ x > 1 \ \wedge \ \textbf{three}(x) \ \wedge \ \text{CHILD}(x) \ \wedge \ [e] \ \wedge \ e = 1 \ \wedge \ \text{HUG}(e) \ \wedge \ \text{TH}(e, x)$

Henderson’s definition for pluractional verbs is somewhat complicated, so I won’t go into detail here (though see Chapter 7 for a related pattern in French Sign Language); in a nutshell, a pluractional weakens the thematic relationship between e and x so that thematic uniqueness no longer comes into play, so dependent indefinites are licensed in sentences with pluractionals.

Turning to non-pluractional cases where dependent indefinites are licensed by another argument, we confront another puzzle: how do we satisfy both the condition that $x > 1$ and that $e = 1$ without weakening thematic uniqueness?

Henderson’s solution comes from the interaction of these two conditions with a distributivity operator: namely, when a distributivity operator is present, Henderson argues that the event singularity condition $e = 1$ is evaluated *within* the distributive scope, and the participant plurality condition $x > 1$ is evaluated *after* the distributive scope has closed.

Henderson delays evaluation of the plurality condition via a mechanism of ‘postsuppositions.’ In classical semantics, *pre*suppositions are a device for accounting for trivalent truth conditions—modeling undefinedness as well as truth and falsity. In a dynamic framework, where meaning is represented as a function from an input context to an output context, presuppositions can be formalized as a condition that must hold of an input context in order for a formula to be defined. For example, if ϕ presupposes ψ, then $[\![\phi]\!]^{\langle G,H \rangle}$ is only defined if ψ is satisfied by the input context G. By analogy, a *post*supposition is a condition that must hold of an output context in order for a formula to be defined. For example, if ϕ postsupposes ψ, then $[\![\phi]\!]^{\langle G,H \rangle}$ is only defined if ψ is satisfied by the output context H.

In practice, what this means is the following: if the formula doesn’t change the context in the relevant way, then the postsupposition essentially behaves like a presupposition; however, because the postsupposition is evaluated after the formula, the formula itself may change the context in such a way to satisfy the postsupposition. The situation can be understood by means of a general paraphrase with a postponed conjunct: if Op is an operator that triggers the evaluation of postsuppositions, then an expression in which a postsupposition ψ appears in the scope of Op is equivalent to an expression in which ψ appears as a conjunct attached after Op has been evaluated, as in (156).

(156) $\text{Op}(A \wedge \overline{\psi} \wedge B) = \text{Op}(A \wedge B) \wedge \psi$

In the case at hand, an indefinite is introduced in the scope of a distributive operator; a postsupposed variation condition, $x > 1$, is evaluated only after the distributive scope has been closed off again, generating a plurality that can satisfy the postsupposition.

Sentence (157) shows how this captures the licensing facts with an example where a dependent indefinite appears below the distributive operator *chikijujunal*, 'each.' The logical form in (158) is equivalent to the translation of (157), with a postsupposed plurality condition.

(157) Chikijujunal ri tijoxela' xkiq'etej **ju-jun** tz'i'.
each the students hug one-one dog
'Each of the students hugged a dog.'

(158) $\textbf{max}^x(\textbf{one}(x) \wedge \text{STUDENT}(x)) \wedge \delta([y] \wedge \textbf{one}(y) \wedge \text{DOG}(y) \wedge [e] \wedge e = 1 \wedge \text{HUG}(e) \wedge \text{AG}(e, x) \wedge \text{TH}(e, y)) \wedge y > 1$

What is important in this example is the fact that the condition $e = 1$ appears within the parentheses demarcating the scope of δ, but the condition $x > 1$ appears after it. As we saw in discussion surrounding Figure 4.4, the singular individuals that are involved in the evaluation of the distributive operator are combined into a plural individual that is available to subsequent computations. Because the condition $x > 1$ appears after distributive scope has closed, this plural individual is available, and the sentence is grammatical.

However, this analysis is fundamentally contingent on the presence of a distributivity operator. Consequently, when a plural licenses a dependent indefinite, it must do so by virtue of a covert distributivity operator. As we saw in Chapter 3, this faces empirical problems.

To restate the problem, when a dependent indefinite is licensed by a plural, it may be conjoined with another indefinite that is interpreted cumulatively or collectively. If licensing by a plural requires the presence of a covert distributivity operator, this distributivity operator will end up scoping over both conjuncts, predicting that the only reading for the plain indefinite is a distributive reading. Example (159), repeated from Chapter 3, illustrates the problem.

(159) **Hungarian** (p.c. Dániel Szeredi)

A diákok két előételt és **egy-egy** főételt rendeltek.
The students two appetizers and one-one main dish ordered.
'The students ordered two appetizers in total, and one main dish each'

In the next section, I will present a new analysis of dependent indefinites. Inspired by the ASL data discussed in Chapter 3, I will propose that there *is* an anaphoric connection between a dependent indefinite and its licensor (as in, e.g. Brasoveanu and Farkas 2011). I will show that this allows licensing by plurals without the need for a covert distributivity operator.

4.5 Proposal for dependent indefinites

4.5.1 Levels of plurality via an anaphoric connection

The guiding intuition of my proposal is the following: Henderson's idea of two levels of plurality is correct, but he is wrong to hard-wire this as two different ways of encoding pluralities. Instead, keeping Brasoveanu 2012's unenriched system, we can capture same idea of levels of plurality by looking at a plurality *with respect to another variable*.

More precisely, given the set $G(y)$ for some information state G, we can divide it into subsets, relative to the value of x in G. Recall from the definitions in (122) and (123) that $G_{x=d}(y)$ is the set of values that y takes on those assignment functions that map x to d. Collecting each set that we get as we let d range over the values of x provides us a way to divide up the value of y into a set of sets. This set of sets is formally defined in (160).

(160) $\{G|_{x=d}(y) : d \neq \star\}$

We can now define properties that are analogous to Henderson's concept of domain-level and evaluation-level plurality. The variable y is an evaluation level plurality with respect to x if the set in (160) has cardinality greater than one. The variable y is a domain level plurality with respect to x if the *elements* of the set in (160) have cardinality greater than one.

Note that this set provides us exactly the granularity of information that we were able to recover from Henderson's architecture. Consider the sentence in (161). Under Henderson's enriched system, it would yield an output state like the one in (162a); under Brasoveanu 2012's unenriched system, it would yield an output state like the one in (163a). The information contained in (163b) is precisely the information contained in (162b).

(161) Every boy saw two girls.

(162) a. $G =$

x	y
a	d ⊕ e
b	f ⊕ g
c	h ⊕ i

b. $G(y) = \{$d ⊕ e, f ⊕ g, h ⊕ i$\}$

(163) a. $H =$

x	y
a	d
a	e
b	f
b	g
c	h
c	i

b. $\{G|_{x=d}(y) : d \neq \star\} = \{\{d, e\}, \{f, g\}, \{h, i\}\}$

This is the point of balance, the theoretical trade-off: the degree of freedom that I gain by introducing an anaphoric component allows me to simplify the architecture of the system, eliminating the use of sum-individuals and the star-operator for cumulative readings.

4.5.2 Definitions

I adopt the Dynamic Plural Logic of Brasoveanu 2012, including the definition of $[x]$ and δ_x. For the sake of a clear compositional semantics, though, I will provide a system with direct interpretation, instead of using the intermediate logic that has been used for exposition so far. This will be accompanied by a shift in notational conventions: throughout §4.5, the interpretation brackets $[\![\cdot]\!]$ will appear around natural language expressions. To facilitate comparison to previous discussion, however, I will reuse the notation from the intermediate logic as a notational short-hand for the relevant semantic functions in the meta-language.

The table in Figure 4.6 provide the types of various important components of the system. Sentences denote propositions, functions that take two information states (an input and and output) and return a truth value.

To avoid overloading the term 'variable,' I adopt the term 'index' to refer to the type of the objects in the domain of an assignment function. Note that the indexes x, y, and z are objects in the object language; I use i, j, k, and l in the metalanguage as variables over these indexes.

Predicates are functions from indexes to propositions. Adapting convention from Brasoveanu 2012 and Henderson 2014, I use SMALL CAPS to refer to the DPlL predicative meaning of the corresponding predicate from classical logic.

Type		Variables	Example
truth value			true, false
index		i, j, k, l	w, x, y, z
entity		d, e	john, mary
integers		n, m	1,2
predicate	index → proposition	P, Q, N	LEFT, ZEBRA
assignment function	index → entity	g, h	x y al | eve
information state	assign. fn. → truth value	G, H	x y al | eve ed | ann
proposition	inf. state → inf. state → truth value	φ, ψ	

Figure 4.6: List of types for fragment

I will begin by repeating definitions that we have seen already in the form that I will use them. As before, $G(i)$ is the set of defined values at index i.

(164) $G(i) \quad := \quad \{g(i) | g \in G \ \& \ g(i) \neq \star\}$

$G|_{i=d}$ is the substate of G with the value of index i restricted to d.

(165) $G|_{i=d} \quad := \quad \{g | g \in G \ \& \ g(i) = d\}$

Given two assignment functions, $g[i]h$ holds if h is identical to g except at i.

(166) $g[i]h \quad \Leftrightarrow \quad$ for any index j, if $j \neq i$, then $g(j) = h(j)$

Like Brasoveanu 2012 and Henderson 2014, variable introduction introduces a plural as the value for a new index, leaving dependencies between all other indexes intact.

(167) $G[i]H \quad \Leftrightarrow \quad$ for all $g \in G$, there is a $h \in H$ such that $g[i]h$, and
for all $h \in H$, there is a $g \in G$ such that $g[i]h$

We define $[j]$ as the function that introduces a set of individuals at some index j.

(168) $[j] \quad := \quad \lambda GH.G[j]H$

Conjunction passes information states asymmetrically through its conjuncts.

(169) $\varphi \wedge \psi \quad := \quad \lambda GH.\exists K.\varphi(G)(K) \ \& \ \psi(K)(H)$

For any n-place predicate P with classical logic denotation $I(P)$, the DPlL denotation P checks that $I(P)$ holds of the value of some n indexes on each assignment function in the information state. I use SMALL CAPS for predicates in DPlL.

(170) $P(i_1, ..., i_n) \quad := \quad \lambda GH.G = H \ \& \ \forall g \in G.\langle g(i_1), ..., g(i_n)\rangle \in I(P)$

The distributive operator δ_i evaluates the proposition in its scope with respect to each substate with i restricted to a different individual d, then returns the union of the output substates, as in Figure 4.4.

(171) $\delta_i(\varphi) \quad := \quad \lambda GH.G(i) = H(i) \ \& \ G|_{x=\star} = H|_{x=\star} \ \& \ \forall d \in G(i).\varphi(G|_{i=d})(H|_{i=d})$

In order to define the quantifier *each*, we will also need a maximality operator that ensures that every single individual in the restrictor is considered by the distributive operator. This will not interact in any particularly interesting way in the system that we have built, but is included for completeness. We adapt the definition for *max* from Brasoveanu 2012.

(172) $\mathbf{max}_i(\varphi) \quad :=$
$\lambda GH.([x] \ \wedge \ \varphi)(G)(H) \ \& \ \neg\exists H'.H(x) \subset H'(x) \ \& \ ([x] \ \wedge \ \varphi)(G)(H')$

Turning to cardinality judgments, I provide new definitions that encode the notion of levels of plurality with respect to an index. For a given set of sets S, recall that we can measure the cardinality of two different aspects of S: an 'outside' cardinality measurement checks that the cardinality of S itself is a certain number; an 'inside' cardinality measurement checks that the cardinality of each *element* of S is a certain number. I use **outside** and **inside** to refer to these notions, applied to the values of j restricted by the values of i.

(173) $\textbf{inside}(j/i) = n$
$:= \lambda GH.G = H \ \& \ \forall T \in \{H|_{i=d}(j) : d \neq \star\}.|T| = n$

(174) $\textbf{outside}(j/i) > 1$
$:= \lambda GH.G = H \ \& \ |\{H|_{i=d}(j) : d \neq \star\}| > 1$

To connect these definitions to what we have seen before, note that the predicate '**outside**$(j/i) > 1$' is a dynamic test that checks that j is dependent on i, in the sense of Nouwen 2003, defined in (125) and repeated in (175).

(175) In an information state G, j is dependent on i iff
$\exists d, e \in G(i).G|_{i=d}(j) \neq G|_{i=e}(j)$

To check the cardinality of $G(i)$ as whole, I use the function in (176). I retain the notation **inside** to emphasize formal similarity with the case where j is restricted by i.[8]

(176) **inside**$(j) = n$
$:= \lambda GH.G = H \;\&\; |H(j)| = n$

We are now in a position to provide lexical definitions. Following are the predicates that I will use in derivations.

(177) a. $[\![\text{students}]\!] = \lambda j.\textsc{students}(j)$
b. $[\![\text{zebras}]\!] = \lambda j.\textsc{zebras}(j)$
c. $[\![\text{left}]\!] = \lambda j.\textsc{left}(j)$
d. $[\![\text{saw}]\!] = \lambda j.\textsc{saw}(j)$

Note that the output to all these functions is a propositional type—i.e. a function from a pair of information states to a truth value. I have just 'hidden' the information states in these definitions through the use of the short-hand introduced above. So, for example, $[\![\text{zebras}]\!]$ is in fact a function that takes an index (j), then two information states (G and H), then returns a truth value.

A plain numeral is given a meaning as in (178). A plain numeral built from the integer n introduces an index j, checks that j satisfies the predicates of its two complements, then checks that there are exactly n distinct values in $G(j)$.

(178) $[\![\text{three}_j]\!] = \lambda NP.[j] \;\wedge\; N(j) \;\wedge\; P(j) \;\wedge\;$ **inside**$(j) = 3$

A dependent numeral is given a meaning as in (179). Here, I use the pseudo-English *two-two* to stand in for a dependent indefinite like we see in Telugu, Kaqchikel, and so on. A dependent numeral built from n and anaphoric to an index i introduces an index j, checks that j satisfies the predicates of its two complements, checks that there are at least two distinct sets in the value of $G(j)$ restricted by i, then checks that each of these sets has cardinality n.

(179) $[\![\text{two-two}_{i,j}]\!] =$
$\lambda NP.[j] \;\wedge\; N(j) \;\wedge\; P(j) \;\wedge\;$ **outside**$(j/i) > 1 \;\wedge\;$ **inside**$(j/i) = 2$

[8]In principle we could give a general definition of **inside**(i/V), where V is a set of indexes; **inside**(i) would be the special case where V is the empty set. Note that along the same lines, **outside**(i) is well-defined, but always equals 1.

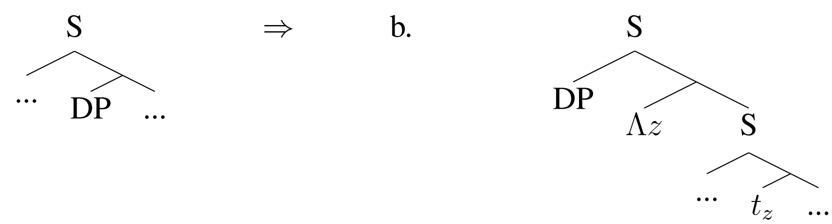
One thing that is important to note about the definition in (179) is the order in which these conditions are evaluated. In particular, the two cardinality checkers are evaluated *after* the two predicates are introduced. What this means is that the cardinality checkers may be dependent on an index that is introduced by a complement of the dependent indefinite. This is the reflection in my analysis of Henderson 2014's insight that the plurality condition of a dependent numeral is somehow 'postsuppositional.' However, my system does not encode this through an enrichment to the architecture, but instead as a property of a lexical definition.

Finally, we define *each*, as follows. *Each* introduces an index i, checks that this variable contains the maximum set of individuals in its restrictor N, evaluates the proposition that the predicate P holds of i for each value of i, then returns the union of the output states.

(180) $[\![\text{each}_i]\!] = \lambda NP.\mathbf{max}_i(N(i)) \ \wedge \ \delta_i(P(i))$

I assume that quantifiers can move by Quantifier Raising (QR) as in standard analyses of scope. Notationally, I use the following convention for QR: given a logical form matching the schema in (181a), I assume that you can derive a logical form matching the schema in (181b).

(181) a. ⇒ b.



4.5.3 Examples

In this section, I work through several derivations to show how the system works. I include one derivation of a sentence without a dependent indefinite, one sentence with a dependent indefinite licensed by a plural (without a distributivity operator), and one derivation of a dependent indefinite licensed by a distributive operator. Like the definitions above, the sentences I am deriving are not any specific language, but are taken to stand in for the licensing patterns and interpretations that were described cross-linguistically in examples (256)–(238).

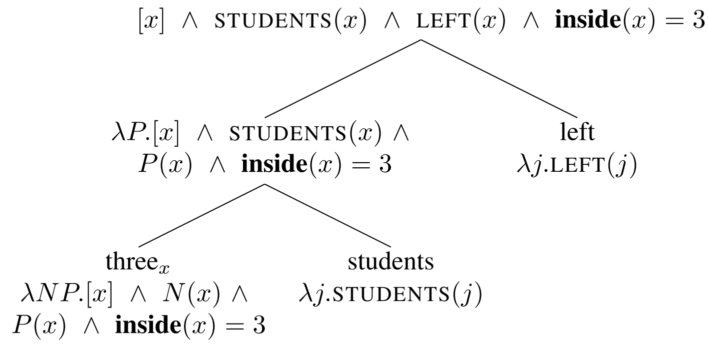
Example (182a) provides a sentence without a dependent indefinite. The derivation for the logical form in (182b) is shown in (183). Working step by step through the logical form, the sentence says the following: given an input state G, $[x]$ introduces a plurality of individuals across the cells of a column (the index x); $\text{STUDENTS}(x)$ is a test that checks that each cell in x is a student; $\text{LEFT}(x)$ checks that each cell in x left; $\mathbf{inside}(x) = 3$ checks that there are three distinct values in the cells of x. The sentence is true of any output states H—that is, any states where there are three students who left.

(187) provides some possible output contexts for the sentence evaluated in a neutral context.

(182) a. Three$_x$ students left.

b. $[x] \ \wedge \ \text{STUDENTS}(x) \ \wedge \ \text{LEFT}(x) \ \wedge \ \mathbf{inside}(x) = 3$

(183)



(184)

student_1
student_2
student_3

student_4
student_2
student_2
student_3

student_4
student_1
student_2

...

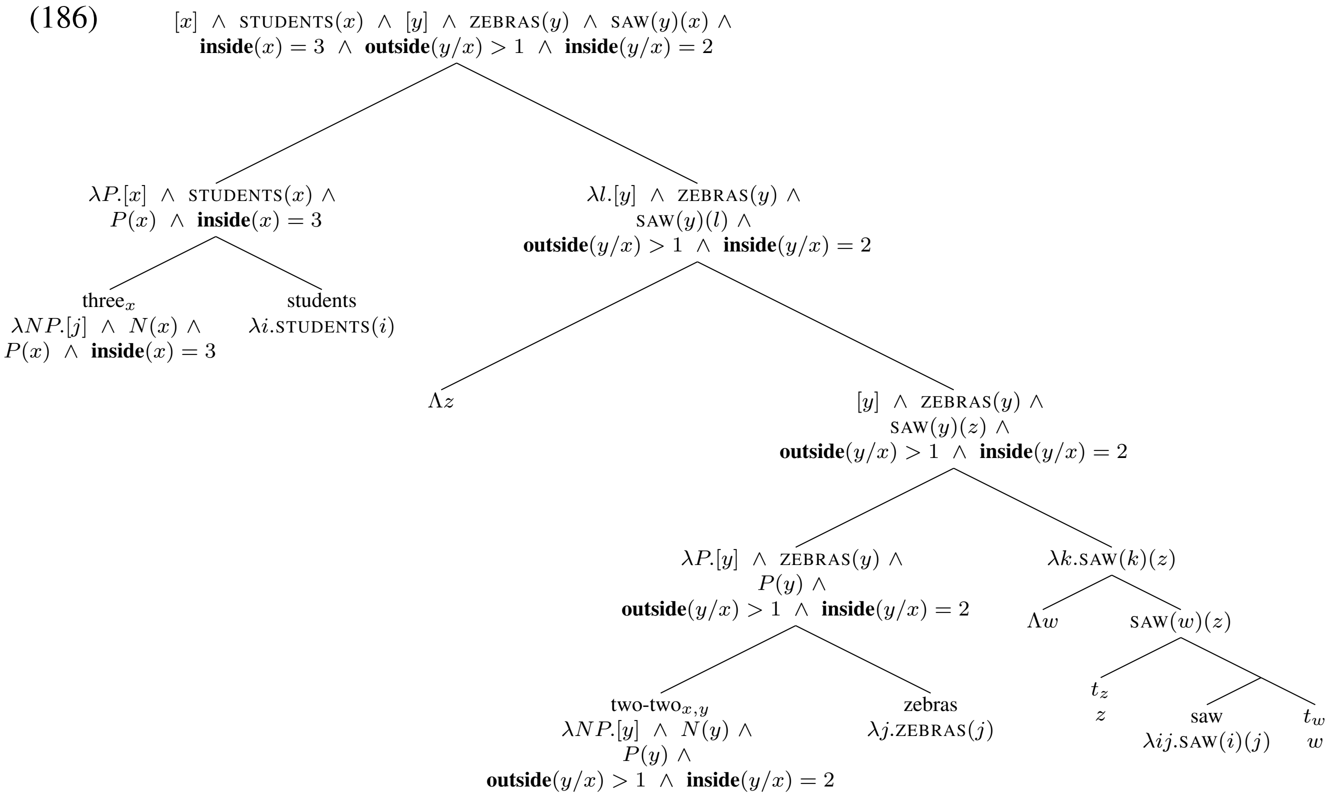
Example (185a) provides a sentence with a dependent indefinite licensed by the plural *three students*. The derivation for the logical form in (185b) is shown in (186). Working step by step through the logical form, the sentence says the following: given an input state G, $[x]$ introduces a plurality of individuals across the cells of index x; STUDENTS(x) is a test that checks that each cell in x is a student; $[y]$ introduces a plurality of individuals across the cells of index y; ZEBRAS(y) is a test that checks that each cell in y is a zebra; SAW$(y)(x)$ checks that the value of x in each row saw the value of y in that row; **inside**$(x) = 3$ checks that there are three distinct values in the cells of x; **outside**$(y/x) > 1$ checks that the values of y depend on the values of x; **inside**$(y/x) = 2$ checks that there are two distinct values of y for each value of x. The sentence is true of any output states H—that is, any states where there are three students who saw zebras, they didn't all see the same zebras, and there are two zebras per student.

(187) provides some possible output contexts for the sentence evaluated in a neutral context.

(185) a. Three$_x$ students saw two-two$_{x,y}$ zebras.

b. $[x] \wedge$ STUDENTS$(x) \wedge [y] \wedge$ ZEBRAS$(y) \wedge$ SAW$(y)(x) \wedge$ **inside**$(x) = 3 \wedge$ **outside**$(y/x) > 1 \wedge$ **inside**$(y/x) = 2$

(186)



(187)

$student_1$	$zebra_1$
$student_1$	$zebra_2$
$student_2$	$zebra_1$
$student_2$	$zebra_2$
$student_3$	$zebra_1$
$student_3$	$zebra_3$

$student_1$	$zebra_1$
$student_1$	$zebra_2$
$student_2$	$zebra_3$
$student_2$	$zebra_4$
$student_3$	$zebra_5$
$student_3$	$zebra_6$

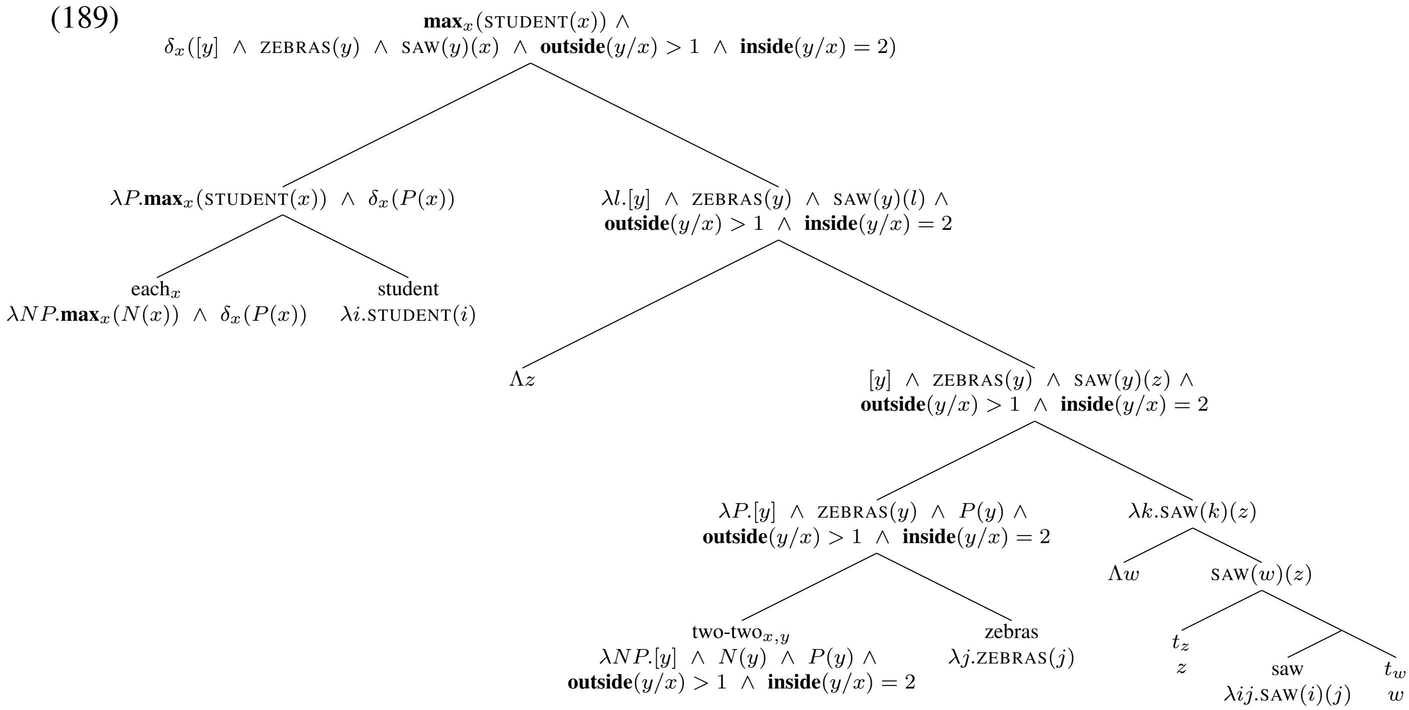
...

Finally, we consider licensing by a distributive operator, as in the sentence in (188a). First, we consider a derivation that fails. In the tree in (189), the distributive operator *each* scopes outside the dependent indefinite *two-two*. The result of this is that the variation condition—i.e., the condition that $\textbf{outside}(y/x) > 1$—appears inside the distributive scope of δ_x, so is evaluated with respect to a substate of G where x is restricted to a single value. The variation condition needs at least two values of x to compare, so the variation condition cannot be met, and the derivation fails.

(188) a. Each$_x$ student saw two-two$_{x,y}$ zebras.

b. $\textbf{max}_x(\text{STUDENT}(x)) \wedge$
$\delta_x([y] \;\wedge\; \text{ZEBRAS}(y) \;\wedge\; \text{SAW}(y)(x) \;\wedge\; \textbf{outside}(y/x) > 1 \;\wedge\; \textbf{inside}(y/x) = 2)$

(189)



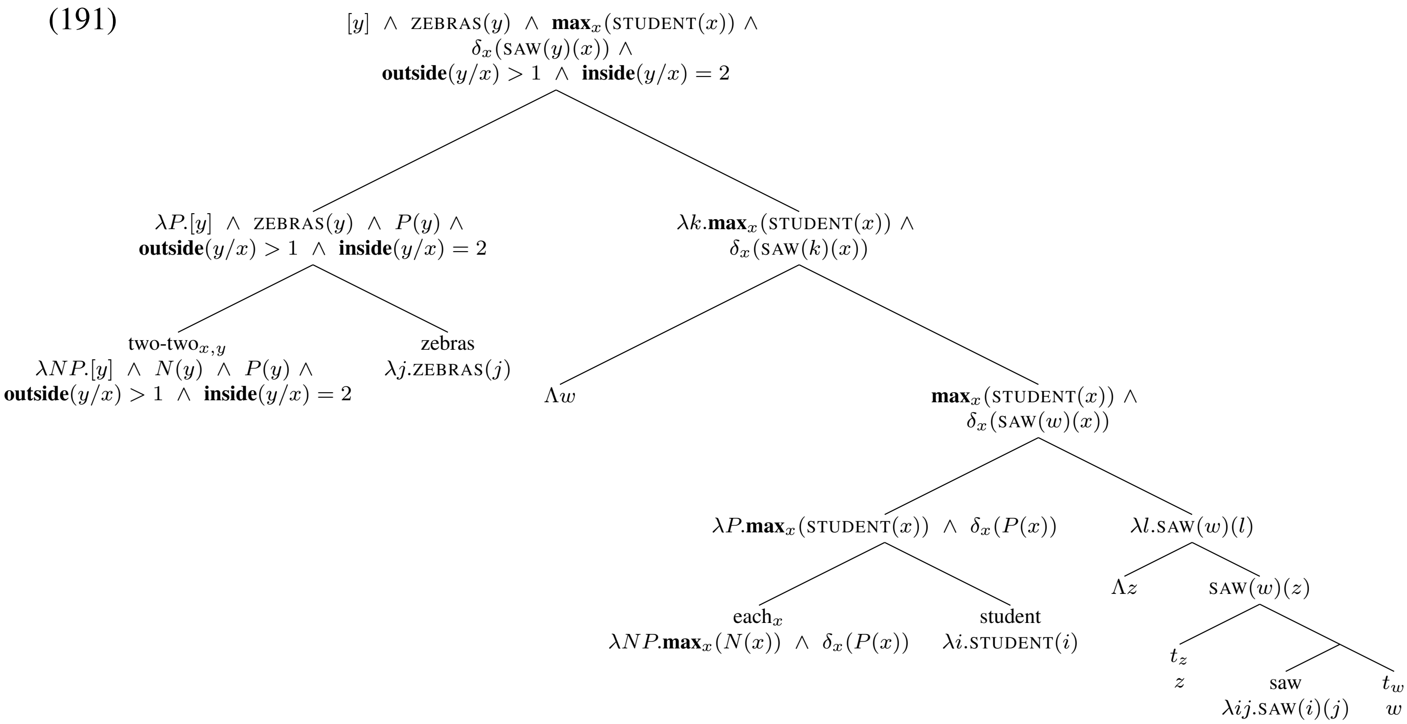
On the other hand, if the dependent indefinite takes scope outside the distributive operator, the derivation succeeds. The tree in (191) derives the logical form in (190b). In (190b), the only expression occurring in the distributive scope of δ_x is the relation $\text{SAW}(y)(x)$; of note, the variation condition that $\textbf{outside}(y/x) > 1$ appears after this scope has closed, giving it access to the full set of values of x and y.

The logical form says the following: given an input state G, $[y]$ introduces a plurality of individuals across the cells of index y; $\text{ZEBRAS}(y)$ is a test that checks that each cell in y is a zebra; $\textbf{max}_x(\text{STUDENT}(x))$ introduces the maximum set of boys across the cells of index x; $\delta_x(\text{SAW}(y)(x))$ divides the state into substates restricted by the value of x, checks that the value of x in each row saw the value of y in that row, then collects the substates again; $\textbf{outside}(y/x) > 1$ checks that the values of y depend on the values of x; $\textbf{inside}(y/x) = 2$ checks that there are two distinct values of y for each value of x. The sentence is true of any output states H—that is, any states where the maximal set of students saw zebras, they didn't all see the same zebras, and there are two zebras per student.

(190) a. Each$_x$ student saw two-two$_{x,y}$ zebras.

b. $[y] \wedge \text{ZEBRAS}(y) \wedge \mathbf{max}_x(\text{STUDENT}(x)) \wedge$
$\delta_x(\text{SAW}(y)(x)) \wedge$
$\mathbf{outside}(y/x) > 1 \wedge \mathbf{inside}(y/x) = 2$

(191)



4.5.4 Analysis sketch: *same*

Turning to *same*, a parallel analysis can be sketched. As with dependent indefinites, *same* considers subparts of the plurality introduced by the DP containing *same*. Dependent indefinites check that of each of these subparts has a certain cardinality; the adjective *same* checks that each of these subparts are identical to each other.

In Chapter 3, I reviewed arguments that *same* presupposes not a plurality of individuals, but a plurality of events. For example, I discussed Barker's observation that the sentence in (192) cannot be used to describe a single event in which John sold Mary a book.

(192) John sold and Mary bought the same book. (Barker 2007)

In the fragment that has been developed to this point, I have not included event variables, nor a way to associate an event with its arguments. As the present analysis is already quite complex, I will not do so here.

Nevertheless, without developing an event semantics, the first approximation of an analysis can still be sketched by providing an account for type-identity uses of *same*. Specifically, we note that the adjective *same* can be used to describe not only scenarios oftoken-identity, but also those of type-identity (Nunberg 1984, Lasersohn 2000). For example, the sentence in (193) may be used naturally to describe a situation in which John and Mary read two different copies of the same work of literature—there are multiple book tokens, but a single book type.[9]

(193) John and Mary read the same book.

The definitions in (194) and (195) account for the subset of data in which *same* communicates type-identity. Let j be the index introduced by the DP containing *same*; let i be the index introduced by a plural licensor. As with dependent indefinites, *same* considers the set $\{H|_{i=d}(j) : d \neq \star\}$—that is, the sets of values taken by j in the substates where G is restricted by the value of i. The adjective *same* entails that each of these sets are type-identical. I use the notation '$\equiv$' to indicate that two objects are equivalent with respect to type-identity.

Note that the lexical definition of *same* in (195) includes the variation condition '**outside**$(j/i) > 1$'. As in the case of dependent indefinites, this condition will ensure that *same* is licensed by a plural.

(194) **same**$(j/i) \quad := \quad \lambda GH.G = H \ \& \ \forall S, T \in \{H|_{i=d}(j) : d \neq \star\}.S \equiv T$

(195) $[\![\text{the\_same}_{i,j}]\!] = \lambda NP.[j] \ \wedge \ N(j) \ \wedge \ P(j) \ \wedge$ **outside**$(j/i) > 1 \ \wedge$ **same**(j/i)

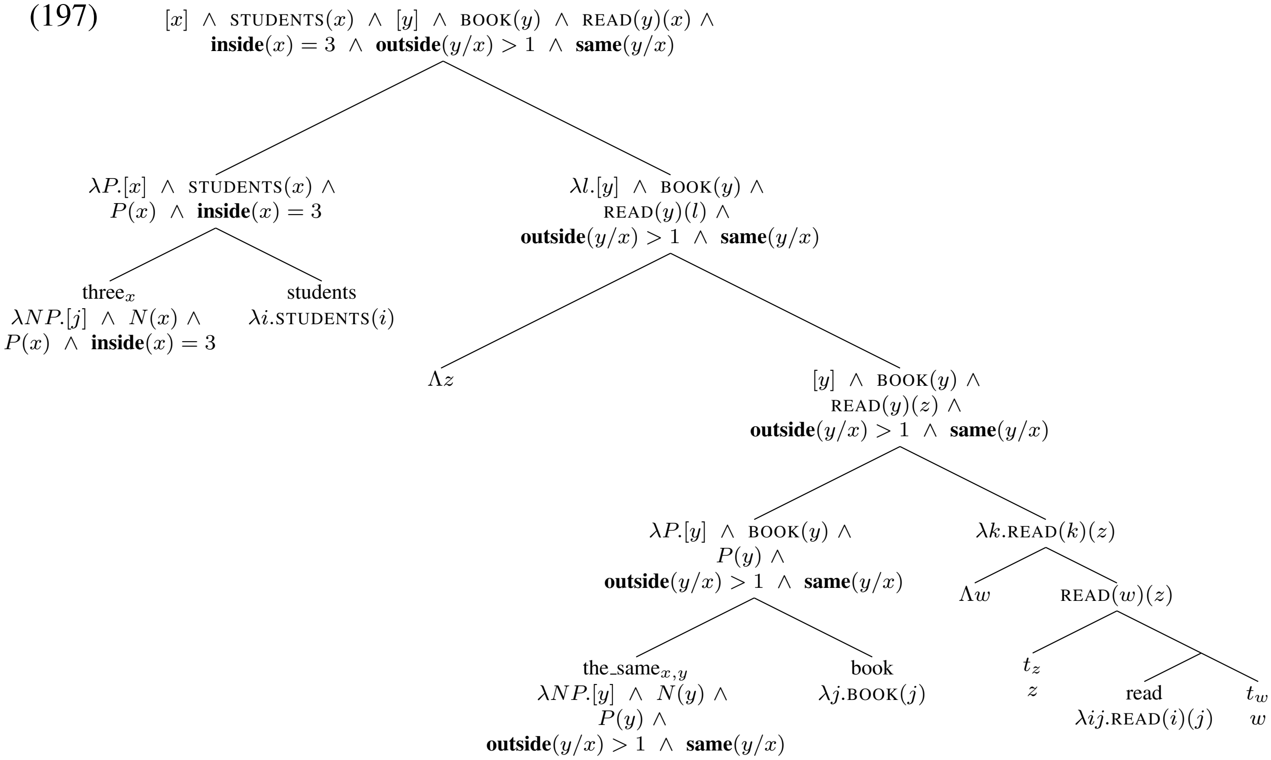
The following derivations provide two examples of *same* in action. The tree in (197) provides a derivation for the sentence in (196), where *same* is licensed by an indefinite plural.

(196) a. Three students read the same book.

b. $[x] \ \wedge \ \text{STUDENTS}(x) \ \wedge \ [y] \ \wedge \ \text{BOOK}(y) \ \wedge \ \text{READ}(y)(x) \ \wedge$
inside$(x) = 3 \ \wedge$ **outside**$(y/x) > 1 \ \wedge$ **same**(y/x)

[9] In American Sign Language, preliminary investigations with Itamar Kastner suggest that the agreeing form of SAME that is discussed here (with a Y-handshape) is in fact used most felicitously in cases of type-identity—cases of token-identity are preferably signed with non-agreeing SAME or with another translation of 'same' in which the two hands are brought together with the 1-handshape, palms down. However, these seem to be preferences rather than hard constraints.

(197)

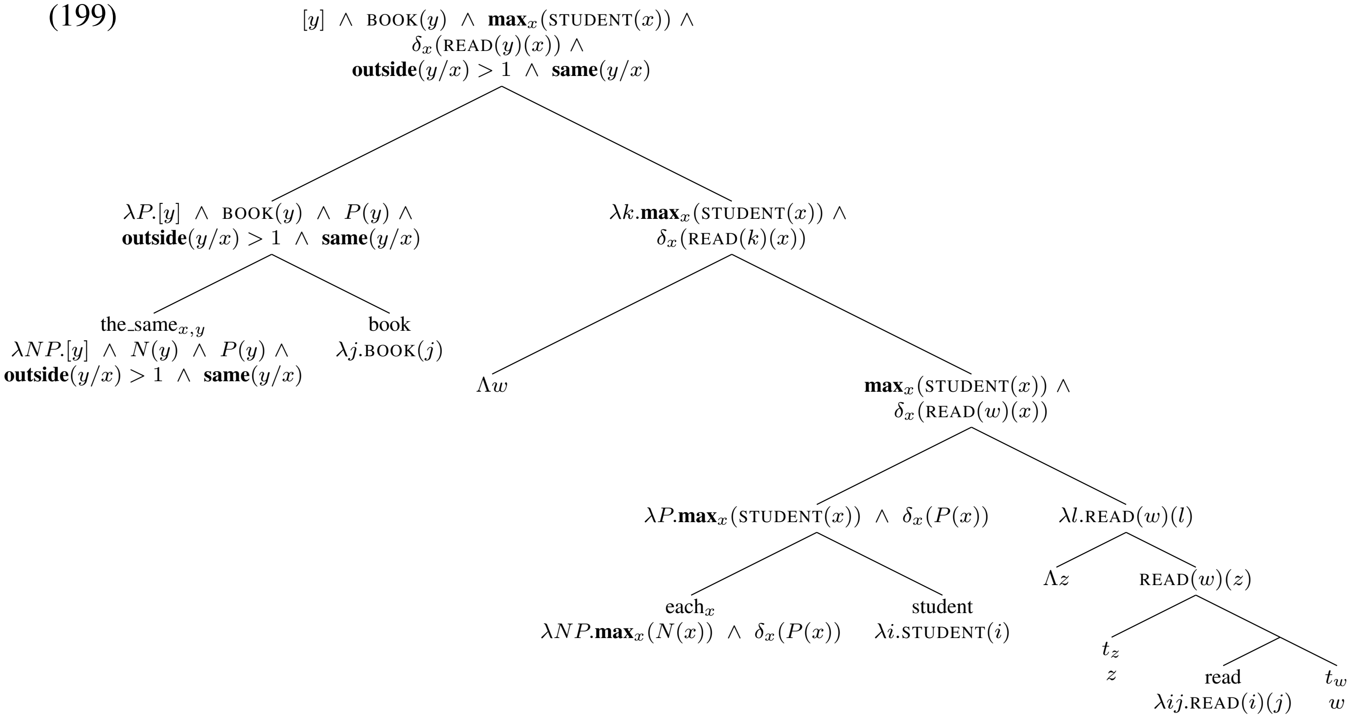


The tree in (199) provides a derivation for the sentence in (198), where *same* is licensed by distributive operator.

(198) a. Each student read the same book.

b. $[y] \wedge \text{BOOK}(y) \wedge \textbf{max}_x(\text{STUDENT}(x)) \wedge$
$\delta_x(\text{READ}(y)(x)) \wedge$
$\textbf{outside}(y/x) > 1 \wedge \textbf{same}(y/x)$

(199)



4.6 Comparison to other analyses

To highlight some features of this system, I will compare the proposal to other recent analyses. I will focus mostly on comparison to Henderson 2014, since it's the closest in spirit and mechanics, but will also include comparison to Balusu 2006, Brasoveanu and Farkas 2011, and Cable 2014. I will address the following two fundamental architectural questions:

1. Do dependent indefinites have an anaphoric component?

2. Are dependent indefinites quantificational?

The latter of these turns out to be connected to a third architectural question:

3. Do dependent indefinites see outside of distributive operators via postsuppositions or standard scope?

In the fragment that I have just presented, my answers to these questions are: Dependent indefinite have an anaphoric component. They are quantificational. They are subject to standard scope.

With respect all three of these questions there is a theoretical trade-off, depending which choice is made, meaning that there is no clear argument from parsimony. However, in each case, I claim that the alternative runs into empirical trouble. And, in each case, the ASL data points towards the answer I give here.

4.6.1 Anaphoric or not?

In the system that I have developed here, dependent indefinites come bearing an anaphoric connection to their licensor. In the derivations that I gave above, this was evident in the fact that there were two subscripts on the dependent indefinite (e.g. *two-two*$_{x,y}$)—one is associated with the discourse referent introduced by the dependent indefinite; the other is associated with its licensor. In this decision to include an anaphoric component, my analysis follows Brasoveanu and Farkas 2011, and is in opposition to Balusu 2006, Henderson 2014, and Cable 2014.

Based on spoken language data, in which no evidence for such anaphoric link is visible, Henderson 2014 suggests that an analysis without such a link is more parsimonious. The situation, though, is not so clear: as we saw in §4.4.3, the cost associated with removing the anaphoric component is that Henderson is forced to enrich his system in other ways—namely, by the addition of sum individuals and a star-operator to generate cumulative readings. By including an anaphoric element, I was able to retain Henderson's insights about levels of plurality without these revisions.

I further argued in §3.6.1 that this choice had empirical consequences: namely, under an analysis without an anaphoric element, the only way for a plural indefinite to license a dependent indefinite was by way of a covert distributivity operator. I argued that this got the wrong results for sentences with dependent indefinites coordinated with plain indefinites.

Finally, we observe that, while spoken language might not show an overt connection between a dependent indefinite and is licensor, in ASL, this link is clearly visible in the phonological form. Any analysis of ASL thus requires some way to specify this formal link.

4.6.2 Quantificational or not?

In the system that I have developed here, dependent indefinites are non-trivially quantificational. To see this point, we can look again at the logical form for the last example that I derived above, repeated here. Of note, observe that the distributive meaning comes not from the distributive operator, but from the expression $\textbf{inside}(y/x) = 2$, which checks that there are two distinct y's for every x. Indeed, when the numeral scopes over *each*, the effect of the distributive operator becomes vacuous—the only thing in its scope is a proposition that independently distributes down to each assignment function in the information state.

(200) a. Each$_x$ student saw two-two$_{x,y}$ zebras.

b. $[y] \ \wedge \ \text{ZEBRAS}(y) \ \wedge \ \textbf{max}_x(\text{STUDENT}(x)) \ \wedge$
$\delta_x(\text{SAW}(y)(x)) \ \wedge$
$\textbf{outside}(y/x) > 1 \ \wedge \ \textbf{inside}(y/x) = 2$

This is in opposition to the original intuition, expressed in Chapter 3, that the distributive meaning comes from the distributive licensor, and a dependent indefinite takes mandatorily low-scope with respect this licensor. In my system, quite the opposite is the case.

Thus, we have two options: either dependent indefinites are quantificational, or dependent indefinites are synonymous with plain indefinites, but with an extra constraint. In my decision to make dependent indefinites quantificational, my analysis follows Balusu 2006 and Cable 2014, and is in opposition to Brasoveanu and Farkas 2011 and Henderson 2014.

Here again, though, empirical matters come into play. First, an analysis with with non-quantificational dependent indefinites must explain how they receive their meaning under plural licensors. Again, the analysis must make recourse to a covert distributivity operator, which raises the familiar problems.

Moreover, if we pursue Henderson's insight that dependent indefinites check for a plurality outside the scope of a licensing distributivity operator, we are forced to assign them a sort of *split scope*, with the classical meaning interpreted *in situ* and the variation condition interpreted outside of the distributive scope. As we saw in §4.4.4 Henderson achieves this goal through the use of postsuppositions (Brasoveanu 2012); the classical meaning is part of the asserted component while the variation condition is postsupposed. Note, though, that postsuppositions require yet another enrichment to the architecture; in the new system, context is able to not only pass information states through the dynamic computation, but also to pass through a set of propositions (the postsuppositions) to be evaluated at a later point in evaluation.

Aside from the worrisome new complexity of the system, it turns out that postsuppositions introduce new empirical predictions that are not clearly borne out. In particular, in order to be backwards-compatible with Brasoveanu 2014's proposal with postsuppositions, Henderson is required to posit that postsuppositions are always be evaluated at the lowest distributive operator they scope under (see Henderson 2014, example 81). As a result, in sentences with two possible licensors that have a fixed scopal ordering, only one reading is predicted to be possible. In Chapter 3, we saw preliminary evidence involving dependent indefinites in Hungarian that suggests that this prediction is not borne out: namely, in sentences with two potential licensors, a dependent indefinite is able to associate with either licensor.

I'd like to suggest that the ASL data, once again, points in one direction. Specifically, in Chapter 3, I made a point of arguing that the patterns that are visible for dependent indefinites are exactly mirrored by the adjectives SAME and DIFFERENT. Although the semantics of *same* and *different* is complex in itself, what is clear is that these adjectives must compare elements of a set to each other—that is to say, they are quantificational. Inspired by the morphological similarities in ASL, we treat dependent indefinites likewise.

4.7 Summary

In this chapter, I discussed a variety of dependency constructions in natural language, focusing on the case of dependent indefinites, where inflection indicates that the value of one DP varies with respect to another plurality in the sentence. Compositionally, these constructions pose an interesting challenge by virtue of the long-distance relationship between the dependent indefinite and its licensor. The nature of what can serve as a licensor also provides a puzzle: across many languages, dependent indefinites are licensed by plural nouns but not by singulars; yet they also can be licensed by operators that distribute down to atomic individuals.

In this chapter, I adopted Dynamic Plural Logic as an attractive framework in which to analyze these kinds of constructions, since DPlL allows the compositional semantics to keep track of dependency relations between plural discourse referents. I discussed a variety of implementations of DPlL, differing notably on their treatment of cumulative readings.

Analyses of dependent indefinites vary with respect to several architectural questions. First, an analysis must explain the relation between a dependent indefinite and its licensor. On some analyses, this connection is direct (e.g. anaphoric); in others, it arises indirectly through the compositional semantics. Second, an analysis must explain the fact that both plurals and distributive operators can serve as licensors. When plural licensors are taken to be the base case, dependent indefinites under distributive operators are redundantly vacuous; when distributive operators are taken to be the base case, dependent indefinites under plurals must be licensed by a covert distributivity operator. Finally, an analysis must explain the semantic mechanism that allows dependent indefinites to be licensed by operators that distribute down to atomic individuals, but not by singular nouns.

I argued that the ASL data discussed in Chapter 3 gives insight into these questions. Based on the fact that dependent indefinites in ASL show spatial agreement with their licensor, I proposed that dependent indefinites include an anaphoric component (following Brasoveanu and Farkas 2011). Based on the fact that dependent indefinites in ASL are morphologically unified with SAME and DIFFERENT, I argued that dependent indefinites have a similarly quantificational semantics (following Balusu 2006 and Cable 2014).

These two design choices result in more theoretical freedom along certain other dimensions. First, plural nouns are able to license dependent indefinites without the need for a covert distributivity operator; this freed us from a challenge regarding the coordination of plain and dependent indefinites. Second, the variation condition is able to escape from the distributive scope of an operator without the need for postsuppositions: I provided an analysis in which dependent indefinites take wide scope through standard scope-taking mechanisms.

Part II

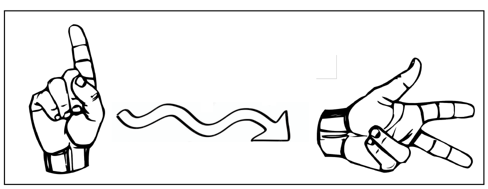
Verbs

Chapter 5

Introduction to Part II: iconicity in the grammar

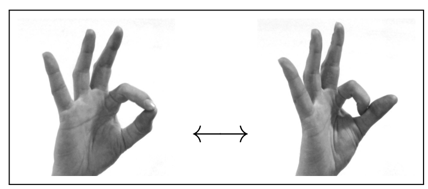
Sign languages, cross-linguistically, are well known for having productive and pervasive iconicity. In loose terms, iconicity means that the form of the sign 'looks like' the meaning of the sign. Figures 5.1a and 5.1b provide two examples from American Sign Language. In Figure 5.1a, an arbitrary wavy motion with an upraised index finger (a '1' handshape) can be used to indicate that a person moved along the same wavy motion. In Figure 5.1b, an 'F' handshape, creating a circle of arbitrary size between the index finger and thumb, can be used to denote a small disk with the same diameter (Emmorey and Herzig 2003).

a.



"The person walked up to the vehicle along a wavy path."

b.



small disk ⟷ smaller disk
(Emmorey & Herzig 2003)

Figure 5.1: Two iconic constructions in ASL

In Part II of this dissertation, iconicity becomes a central theme. Two observations in particular form the backbone of the discussion. First, we observe that pictorial representations are able to express meaning in ways that a combinatorial grammar alone cannot. Second, we observe that these iconic representations nevertheless feed into grammaticalized patterns known from spoken language—patterns involving categorical logical properties like telicity and plurality. In the following chapters, we ask the question: what are the points of *interface* between iconicity and the formal grammar?

To answer this question, it will be necessary to be precise about what it means for something to display iconicity, so that we know what tools we can employ to investigate it. In this introduction, I aim to clarify some of these issues.

5.1 Iconicity and gradient interpretation

Formally, we give the following definition for iconicity.

(201) A structure is **iconic** if there is a non-arbitrary structure-preserving mapping from the form of a sign to its meaning.

An iconic mapping can preserve a number of different kinds of structure, in the way a black and white photo preserves form but not color, or the way the London Tube map preserves the topology of the London Underground (i.e. all the connections), but not its geometry (i.e. all the distances)[1]. In the subsequent chapters, we will be focusing primarily on iconic mappings that preserve *geometric* structure—that is, information about relative measurement. For example, on a mapping where geometry is preserved, a sign with two articulators close together (relative to some contextually determined standard) would receive a meaning in which the close proximity is preserved in interpretation.

If an iconic mapping preserves measurement, an immediate corollary is that gradient phonetic changes will yield gradience in the semantic interpretation. Emmorey and Herzig discuss this result with paradigm involving the stimuli illustrated in Figure 5.1b. As mentioned earlier, an F-handshape can be used to indicate a small circular object; the aperture of the thumb and index finger can be changed to indicate how large the object is. Emmorey and Herzig 2003 show that these sizes exist along a continuum; both signers and non-signers are able to interpret sizes gradiently.[2]

In contrast, generative grammar, as a discrete, combinatorial system, is not able to generate patterns of gradient interpretation.[3] The upshot of these two facts together—that an iconic mapping can preserve gradient structure, but that a discrete system cannot—is that the interpretation of gradient phonetic changes can serve as a diagnostic for iconicity. This is the diagnostic that we will be using here to argue for iconicity in ASL and LSF verbal forms.

[1]The reader is referred to Greenberg 2013 for more examples and discussion of pictorial representation.

[2]The flipside of this pattern is that this iconic effect interacts in an interesting way with the conventionalized size-denoting signs in ASL; in ASL, both the F-handshape and the small-C handshape (middle, ring, and pinky fingers closed) are used to refer to circular objects, but the latter are used for slightly larger circles. Emmorey and Herzig show that signers show a discontinuity of interpretation between iconic representations with F- and C-handshapes while non-signers, with no conventionalized size-indicators, show no discontinuity between the two handshapes.

[3]Patterns of gradient interpretation are not to be confused with the ability to recursively modify forms within a discrete system, as in (i).

(i) a. John is very tired.
 b. John is very very tired.
 c. John is very very very tired.

Specifically, note that although the predicates in (i) arguably express properties with higher and higher cut-off points, there is no way to indicate a cut-off point higher than "very very tired," but not quite as high as "very very very tired" (there is no form "very very ve... tired"). In contrast, to indicate a disk that has a shape halfway between the diameters indicated by two different forms of an F-handshape, a signer can sign the F-handshape with a diameter between the two forms.

A few notes are warranted on the logic of this argument. First, note that the existence of an iconic construction does not necessarily guarantee that gradient interpretation can be found, since, as observed above, the iconic mapping need not preserve geometric structure, and other kinds of structure, like mereological (parthood) structure, may not be sensitive to measurement. To make this point more concrete, the reader is referred to the discussion of complement set anaphora in Schlenker, Lamberton, and Santoro 2013; in their analysis of plural pronouns, parthood relations between areas of space are preserved in the parthood relations in the pronoun meanings, but information about relative size (i.e. the measure of a plural) is not necessarily preserved. Their argument for the existence of an iconic mapping in this construction is thus a more subtle argument from parsimony.

Second, while the existence of gradient interpretation is sufficient to show that there is *something* beyond generative grammar, it is not sufficient in itself to show that this property is necessarily iconicity. Indeed, the idea that phonetic parameters may be both gradient and meaningful should come as no news to sociolinguists, who have shown in many domains that social variables are reflected in potentially gradient phonetic variables.[4] To take an example that is similar to the paradigms explored here, Plichta and Preston 2005 show that gradient manipulations of the diphthong /aɪ/ in American English yield gradient interpretation of the speaker as more or less Southern.

These findings, too, are convincing evidence for an interpretive system that goes beyond traditional generative grammar, yet it seems misguided to call them iconic. The key difference is in the non-arbitrariness of iconicity: although dialectal cues may be interpreted gradiently, there is still an arbitrary relation between, e.g., formant contour and geographic latitude. Other differences relate to the way that the systems interface with the rest of the grammar. For example, the interpretive processes in dialect evaluation seem to take place at a lower level of awareness than interpretation of iconicity. Plichta and Preston 2005 report that subjects often reported the feeling that they were answering at random (despite generating clear and significant results); in contrast, iconic constructions are transparent enough that naïve non-signers can easily guess their meaning (as in Emmorey and Herzig 2003). Finally, for perhaps related reasons, dialect evaluation and iconic processes seem to act very differently with respect to the compositional system; whereas iconic predicates (as we will see) can enter a derivation at a low level and scope below other operators, interpretation of sociolinguistic variables systematically project with a conjunctive meaning.

Thus, the interpretation of gradient phonetic forms is sufficient to prove the existence of some non-combinatorial interpretive process; identifying exactly what this process is requires examining its underlying motivation and investigating how it interfaces with the grammar.

[4]Thanks to Allison Shapp for discussion on this point.

Chapter 6

Telicity and iconic scales in ASL

6.1 Overview

In a series of papers (Wilbur 2003, 2008, 2009; Malaia and Wilbur 2012), Wilbur shows that there is a non-arbitrary form-to-meaning correspondence in the verbal lexicon of several unrelated sign languages (American Sign Language (ASL), Croatian Sign Language (HZJ), and Austrian Sign Language (ÖGS)). Specifically, in these sign languages, she observes that the phonetic form of **telic** verbs systematically differs from that of **atelic** verbs: the former show abrupt deceleration to a stop; the latter do not.

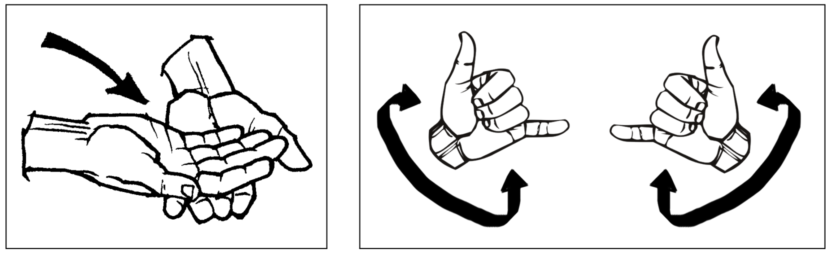
The basic pattern can be illustrated with the signs ARRIVE and PLAY in ASL. The verb *arrive* is telic in ASL and English, as evidenced in English by its incompatibility with *for*-adverbials (as in (202)a); the verb *play* is atelic in ASL and English, as evidenced in English by its grammaticality in the same environment. (Analogous tests hold for ASL, as well.) In ASL, these verbs differ in an important phonetic way as well. The telic verb ARRIVE ends with sharp deceleration ('slamming on the brakes'), as the dominant hand makes contact with the non-dominant hand (see Figure 6.1a)). In contrast, the atelic verb PLAY has no sharp stop, being signed with a back-and-forth twisting motion of the two hands that can be extended to an arbitrary length (see Figure 6.1b))[1].

(202) a. * John arrived for twenty minutes. $\rightarrow$ telic
b. John played for twenty minutes. $\rightarrow$ atelic

This phonetic generalization holds across a wide range of lexical predicates, including psychological and social verbs like PONDER vs. DECIDE and NEGOTIATE vs. BUY.

This phenomenon has been argued to be grounded in a more general cognitive representation of event structure. Malaia 2014 draws connections to psychological work (Zacks et al. 2007)

[1]Sources of images: The images of ARRIVE, CLOSE, and FILL in Figures 6.1 and 6.2 appear courtesy of Bill Vicars and http://www.lifeprint.com/. The diagrams in Figure 6.9 and 6.10 also include an image from http://www.lifeprint.com/. The image of PLAY in Figure 6.1 was drawn using images from Gallaudet-TT font by David Rakowski. All images are used with permission.



ARRIVE PLAY

Figure 6.1: Images of ARRIVE and PLAY in ASL

which shows that the same visual cues (e.g. rate of deceleration) are employed in event segmentation in completely non-linguistic tasks. In a forced-choice meaning-guessing task, Strickland et al. 2015 show that naive non-signers are sensitive to the connection between telicity and the phonetic form of a sign. These findings illustrate a surprising, robust connection between the visual system and abstract, conceptual space.

In sign language, this connection plays an active part in the grammar: Wilbur (2003, 2009) shows that in ASL, the phonetic form can be manipulated in the synchronic grammar with syntactic and semantic effects. These manipulations include stopping the motion of a telic verb before completion, slowing the motion of a verb, and reduplicating a verb in various ways. For example, the verb SIT-DOWN in ASL ends with contact between the signer's two hands; if the sign is produced without this contact at the end, the verb is interpreted roughly as 'almost sat down.'

How are these phonetic effects encoded into the grammar? While acknowledging the iconic origin of these effects, Wilbur (2003, 2009) takes this connection to be purely historical. As far as the synchronic grammar is concerned, Wilbur proposes that phonetic features are discretely codified in the grammar as a finite set of combinatorial morphemes; she argues that the productive patterns emerge from the combination of these sub-lexical morphemes. She takes the sign language data as new evidence in favor of theories of argument structure that posit sub-lexical verbal decomposition (e.g. Ramchand 2008).

In this chapter, I have two goals. First, contra Wilbur, I argue that the iconic mapping from a verb form to its meaning remains active in the grammar (as opposed to just a grounding for a set of morphemes). As evidence, I present examples with gradient interpretive effects that cannot be generated by a discrete combinatorial system alone. I discuss the properties of this iconic mapping.

Second, assuming the new iconic analysis, I turn to the places where phonetic manipulations have categorical, syntactic effects: namely, the telicity divide observed by Wilbur and new data involving *again*-ambiguities. Special consideration will be given to degree achievements (like *rise* and *grow*), which have been shown to have interesting properties with respect to telicity.

I will argue that the data provide new evidence in favor of recent theories in which verbal meanings derive from **scales** (Kennedy and Levin 2008, Pedersen 2014). These theories maintain a decompositional view of verbs (like Ramchand, etc.), but allow some of the sub-verbal arguments to be selected through pragmatic competition. I argue that the phonetic form of verbs in sign language iconically represents these scales, and that categorical effects arise from the way they interact in the pragmatic system.

6.2 Background

6.2.1 Telicity many ways

Natural language is known to grammatically categorize verbs based on their abstract temporal properties. The relevant property—telicity—can be observed in a variety of syntactic and semantic phenomena. Most famous in English is the choice of temporal adverbials: atelic predicates are compatible with *for*-adverbials but not with *in*-adverbials; the opposite holds for telic predicates.

(203) Atelic predicates

a. John {played/pondered the question/negotiated} for 20 minutes.

b. * John {played/pondered the question/negotiated} in 20 minutes.

(204) Telic predicates

a. * John {arrived/decided what to do/bought the car} for 20 minutes.

b. John {arrived/decided what to do/bought the car} in 20 minutes.

Semantically, the division between telic and atelic predicates can be characterized by a property of divisibility: if an atelic predicate holds of an event e, then it also holds of temporally short sub-parts of e. We can formalize this property with Champollion 2010's definition of Stratified Reference, given in (205). Atelic predicates have this property; telic predicates do not. (Here, * returns the algebraic closure of a predicate under sum-formation; τ returns the runtime of an event; ε is a contextually-determined small number.)

(205) Definition: Stratified Reference (SR: adapted from Champollion 2010)

$\text{SR}_\varepsilon(P) := \forall e[P(e) \rightarrow e \in {}^*\lambda e'(P(e') \ \wedge \ \tau(e') \leq \varepsilon)]$

'A predicate P has Stratified Reference if any event e in P can be divided exhaustively into temporally small sub-events that are also in P.'

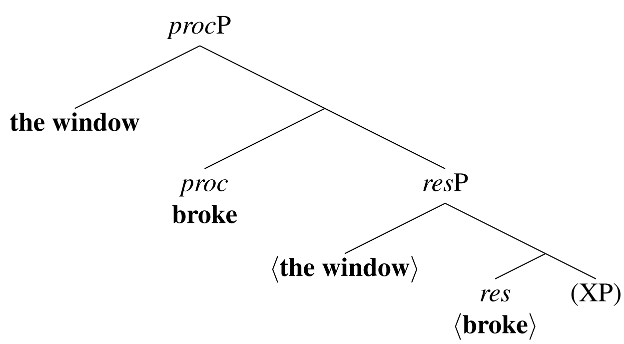
For example, if John slept for several hours, then the event can be divided into 10-minute sub-events, each of which is also a sleeping event. But, if John painted a picture in several hours, it is not possible to divide up the event into short 'painted-picture' events because most sub-events will not include a completed painting. *Slept* satisfies (205) so is atelic; *paint a picture* does not so is telic.

Ultimately, the source of this difference—the reason why telic verbs do not have divisibility/Stratified Reference—is the presence of a **result state** in the meaning of telic verbs. The insight (dating back to Aristotle's *Metaphysics*) is that telic verbs denote events that are more than the sum of their parts. For example, the process of pondering and and the process of deciding are exactly the same; the difference is that the latter results in something new—the decision. The fact that this new state of affairs results from the process as a whole is what prevents divisibility or Stratified Reference from holding of small subevents. (This result state is Aristotle's *telos*, or 'purpose,' from which telicity gets its name.)

A host of syntactic and semantics properties conspire to determine the telicity of a predicate. For example, for some predicates (those with an 'incremental theme'), the telicity of the predicate is determined by the semantic properties of its nominal arguments: '*eat an apple*' (with a count noun) is telic, but '*eat rice*' (with a mass noun) is atelic. For other predicates, the telicity seems to come built-in; for example, '*look at an apple*' and '*look at rice*' are both atelic, regardless of the semantic properties of the noun. (For more discussion of incremental themes, see Krifka 1989, among others.)

Ramchand 2008 argues that verbs are structurally complex, and that the telicity of predicates is in part determined by the sub-lexical decomposition of the verb. Most notably, she argues that a certain class of telic verbs (roughly, those that fall into the Vendler (1957) class of Achievements)), derive their telicity from the presence of a syntactic head *res* that introduces a result state into the lexical meaning. For example, the structure in (206) provides Ramchand's lexical decomposition of the verb *break*, applied to the argument *the window*. Of relevance, the fact that this structure comes with a built-in *res*P means that the verb is necessarily telic.

(206)



Another class of verbs which may be telic are degree achievements that denote progression along some closed scale—e.g., *dry*, *cool*, *straighten* (for more discussion of scales, see §6.4). These verbs have the unique property that they are systematically ambiguous between a telic and atelic meaning, evidenced by their compatibility with both *in*- and *for*-adverbials (as seen in (207)); under the telic reading with *in*-adverbials, they receive the meaning that a change in measure (e.g. dryness) reached its maximal degree.

(207) a. The towel dried in an hour.

b. The towel dried for an hour.

Since these verbs may receive an atelic interpretation, they cannot come with a built-in *res* feature; the telic interpretation must therefore come from somewhere else. Ramchand proposes that, like incremental theme verbs such as *eat*, degree achievements also inherit their telicity from an argument, but that in the case of degree achievements, it is an implicit, scalar argument.

Finally, Ramchand 2008 proposes that a *res* feature may be added to a verb of any class by the addition of a particle. Specifically, in particle-verb constructions like *eat up*, *break off*, and *throw out*, where a particle can be optionally separated from the verb, Ramchand proposes that the particle itself bears a *res* feature. The result is that particle-verb constructions necessarily yield a telic predicate. The example in (208) provides a minimal pair: while the former predicate may be used in an atelic frame, the latter predicate, with a particle, is necessarily telic.

(208) a. I ate the leftover turkey for two weeks.
b. * I ate up the leftover turkey for two weeks.

Thus, the particle in a particle-verb construction is essentially an overt reflection of the *res* feature in English.

To sum up, telic predicates do not get their telicity from a homogenous mechanism. Specifically, we have seen at least four kinds of telic predicates, which pattern in empirically different ways. (I will ultimately be moving away from a theory with a *res* feature, but for discussion of Wilbur's hypothesis, the categories below are described in terms of Ramchand's analysis.) The categories are:

1. Inherently telic verbs, which get their telicity from a *res* feature on the verb. English verbs in this category include: *break*, *throw*, *find*, *explode*, *enter*, *arrive*, *disappear*.

2. Incremental theme verbs, which inherit their telicity from the semantic properties of their complement. English verbs in this category include: *eat* (*an apple*), *paint* (*a picture*), *read* (*an article*).

3. Degree achievement verbs, which inherit their telicity from an implicit scalar complement. English verbs in this category include: *dry*, *cool*, *straighten*, *close*, *fill*.

4. Particle-verb constructions, productively derived by the addition of a particle bearing a *res* feature to a verb of any other class. English predicates in this category include: *break off*, *eat up*, *cool down*.

6.2.2 Visible telicity

Wilbur 2003 observes that lexical predicates in ASL can be classified as telic or atelic based on their phonetic movement. Roughly speaking, telic verbs end with a sharp stop (and often contact with another part of the body); atelic verbs have no such phonetic end-marking. Malaia and Wilbur (2012) provide tentative experimental support for this generalization based on quantitative measurements of lexical predicates in two unrelated sign languages, American Sign Language (ASL) and Croatian Sign Language (Hrvatski Znakovi Jezik, or HZJ). Using 3D motion-capture recordings, they report that both languages show a significant correlation of telicity with several phonetic features (including maximum peak velocity and rate of deceleration following peak velocity). These phonetic effects are dissociable from other properties affecting signing rate like phrase-final lengthening.[2]

However, in light of the many factors that conspire to generate a telic predicate (as discussed in the previous section), the interpretation of Wilbur's generalization is not entirely straightforward. In particular, does the presence of phonetic end-marking correspond to a semantic property of the output form (e.g. lack of Stratified Reference), an abstract morpheme in the syntax (e.g. *res*), or something else?

Wilbur (2008, 2009) takes an explicit stand on this question. She proposes that the phonetic end-marking of telic events in sign language is a reflection of an abstract result state in the sub-lexical decomposition; in Ramchand 2008's terms, it is an overt manifestation of the *res* feature. Essentially, then, the sharp stop of ARRIVE is a reflection of the same abstract morpheme instantiated by the *up* of *eat up*. On Wilbur's analysis, the sign language data thus provides another kind of evidence for the sub-lexical decomposition of verbs.[3]

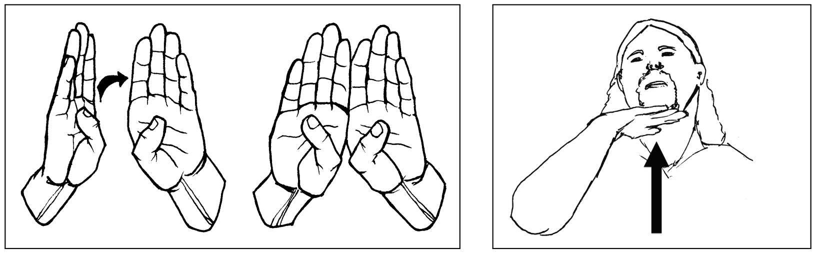
Wilbur 2008 provides evidence for the claim that phonetic end-marking in ASL has a syntactic status by showing that it can be manipulated with semantic effect. For example, the sign for ARRIVE is made by moving the dominant hand to make contact with the non-dominant hand, as shown in Figure 6.1a; if the sign is produced without this end-marking, the sign is interpreted roughly as 'almost arrived' (Liddell 1984). Wilbur 2008 argues that this meaning results from an 'incompletive' morpheme (similar to English *almost*) that modifies the result state instantiated by contact between the hands.

When we consider Wilbur's theory in the more precise terms discussed above, however, the generalization becomes somewhat more shaky. In particular, we face seeming counterexamples when we consider telic degree achievements like *close* and *fill*. In ASL, the sign CLOSE (a door) is made by moving the dominant hand to make contact with the non-dominant hand, as seen in Figure 6.2a. The verb *fill* is signed in several ways in ASL; Figure 6.2b shows the sign GET-FULL (as in, 'I got full from eating so many cookies'), where the hand makes contact with the chin.

These two verbs show end-marking and are telic; thus, at a first pass, they may seem to support Wilbur's hypothesis. But although the verbs are telic, we saw evidence from English that they do not bear a *res* feature; instead, they inherit their telicity from an implicit scalar complement. These verbs thus provide a counterexample to the claim that end-marking is the overt spell-out of *res*.

[2]For statistical reasons, some caution should be taken when interpreting these results. The results show that *some* phonetic marker relating to velocity and deceleration is correlated with telicity, but the five kinematic variables are highly correlated and were each tested individually, which makes it impossible to conclude anything substantive about specific phonetic cues. There are also some questions regarding stimuli selection; notably, the verbs translated as *send* and *interrupt* were puzzlingly categorized as atelic in ASL. (Regardless of translation issues, in other work, Wilbur 2009 categorizes SEND as telic in ASL.)

[3]Other theoretical commitments of Wilbur are less clear: does end-marking instantiate *res* only when it is part of a lexical specification, or can end-marking act like English particles, productively attaching to verbs to make them telic?



a. CLOSE b. GET-FULL

Figure 6.2: Images of CLOSE and GET-FULL in ASL.

Naturally, we can't conclude anything about ASL signs just by looking at their closest English translation; these arguments must be made based on ASL-internal data. Nevertheless, the examples with CLOSE and FILL are suggestive that Wilbur's generalization about the distribution of end-marking (namely, as the spell-out of *res*) is not quite the correct natural class.

In what follows, I will argue that, in general, Wilbur's theory is not able to capture the full range of data; in particular, I will show that there are more manipulations that can be done to verbs in ASL than can be described by manipulating *res* and other discrete morphemes. I will argue that these data must be described through an iconic mapping.

Like Wilbur (and Ramchand, etc.), I will adopt a theory with sub-verbal decomposition. Departing from these theories, however, I will follow Kennedy and Levin 2008 in the proposal that all verbs (not just degree achievements) are decomposed into a logical form with a scale (e.g. for *widen*, the scale is the totally-ordered set of possible widths). I will propose that verbs in ASL display an iconic mapping that represents change along this scale. End-marking is the iconic representation of the closed end of a scale.

This analysis will yield a natural class that cleanly encompasses both 'inherently telic' verbs like ARRIVE and telic degree achievements like CLOSE: both are built from scales with a closed end-point. The difference between the two is that verbs like ARRIVE are built from degenerate scales that only have two points: 0 and 1 (although a richer scale can often be coerced by iconic manipulations). Adopting Kennedy and Levin 2008's scale-based theory of telicity will allow us to derive the fact that end-marking generates telic predicates.

6.3 Iconic manipulations

Here, I will argue that manipulations of the phonetic form of verbs are interpreted iconically in ASL. As background, I will start with the manipulations described by Wilbur, along with her analysis. I will then show that the phenomenon is more general than Wilbur's analysis allows, and that the manipulations Wilbur describes arise as a special case of this more general mapping.

6.3.1 Wilbur's observations

Wilbur (2003, 2008, 2009) shows that the phonetic form of a sign can be manipulated with semantic effects. She discusses several classes of examples, including extended path movement, incompletive marking, and reduplication. Wilbur analyzes these as arising from the combination of discrete morphemes.

First, Wilbur 2008 observes that the motion of a sign may be elongated to indicate an elongated event. Specifically, when a sign includes a 'path motion'—i.e. movement from one position to another—the duration of the motion can be extended from the default speed, often by adding an arc movement. The resulting semantic inference is that the event occurred slowly. For example, when ARRIVE is signed slowly in (209), the interpretation is that the arrival happened slowly.

(209) FINISH-LINE I SEE, ARRIVE-slow.
'I saw the finish line, then arrived at it slowly.'

Wilbur analyzes this elongation of the sign as a morpheme [extra] with an adverbial meaning (something like 'over an extended time'). This analysis makes the prediction that there are only two possible forms of a verb with respect to this manipulation: either the verb has [extra] or it doesn't.

Second, as mentioned above, a path movement can be halted before completion of the sign to produce an incompletive meaning for a telic verb (as mentioned above for ARRIVE). Wilbur 2008 reports, following Smith 2007, that there are in fact two forms of the incompletive. If the sign is halted immediately after it begins, then it is interpreted as meaning that the event barely even started to happen.

(210) I SIT-DOWN-unrealized-inceptive.
'I almost started to sit down.' (from Wilbur 2008)

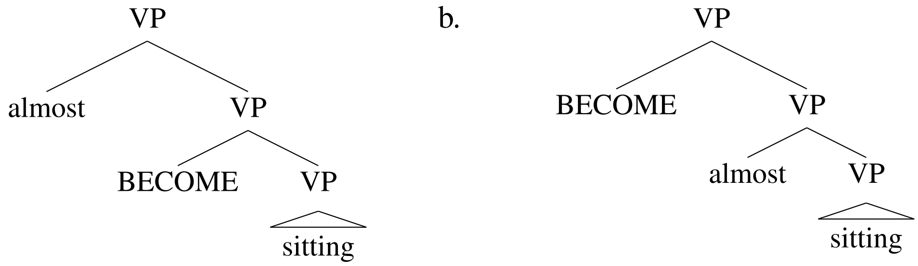
If the sign is halted immediately before it would otherwise be completed, then it is interpreted as meaning that the event started to happen but didn't quite finish.

(211) I SIT-DOWN-incomplete.
'I almost sat down (but stopped myself before contacting the seat).'
(from Wilbur 2008)

Wilbur proposes that both of these forms are the spell-out of an incompletive morpheme that has a meaning similar to English *almost*. In particular, she notes that English *almost* is known to be ambiguous with telic events in English, producing meanings similar to the ones described for (210) and (211) above. This ambiguity has been argued to result from an attachment ambiguity (e.g., Dowty 1979, Pustejovsky 1991).

(212) I almost sat down. (English)

(213) a. b.



Wilbur argues, following Smith 2007, that the two forms in (210) and (211) correspond to the attachment of the incompletive morpheme at different heights. Though Wilbur is not explicit about this point, we are led to understand that the morpheme is spelled out by deleting the phonological realization of its complement.[4] The result is that the two structures are disambiguated, depending how much phonological material is deleted.

This analysis makes explicit predictions: namely, there can be only as many incompletive forms as there are syntactic levels where the incompletive morpheme can attach. If there are two levels (as suggested by the two readings English *almost*), then there should be exactly two distinct incompletive forms in ASL.

Finally, Wilbur 2009 discusses cases of reduplication in ASL, which give a predicate a pluractional meaning. Myriad reduplicative verbal forms have been described in ASL, including ones labeled 'durative,' 'iterative,' 'continuative,' 'incessant,' and 'habitual' (Klima and Bellugi 1979). Wilbur argues that a wide typology of these forms can be generated based on what subtree of the verbal decomposition is targeted by the reduplicative morpheme, and whether the morpheme [extra] appears on these subtrees. Because the issues introduced by plurality are quite complicated, I will not discuss reduplication in depth here, but Chapter 7 returns to the topic of pluractional inflection in LSF and ASL, where it is argued that these constructions also display an iconic mapping.

6.3.2 The iconic mapping

I will argue that an iconic mapping preserves gradient temporal information contained in the phonetic form of a verb. Specifically, when a verb has a phonological path motion (i.e. when it moves without regression from one position in space to another), I will argue that this path is iconically mapped to the temporal progression of the event the verb denotes.

Intuitively, the effect of this mapping should feel very similar to the patterns described by Wilbur: for example, an extended phonetic path is interpreted as a temporally extended event; an incomplete motion is interpreted as an incomplete event. The difference, though, is that an

[4]Note that Wilbur is forced to say that the incompletive construction is formed by the *addition* of an incompletive morpheme (instantiated by removing segments from the phonological form) as opposed to the *removal* of the result state in the syntax. This is necessary because the events denoted by incompletive verbs are still telic events (as seen in (214)); literally removing the result state would incorrectly make the predicate atelic.

(214) ?? ME SIT-incomplete (FOR) ONE MINUTE.

iconic mapping is more general and more powerful, allowing manipulations that cannot be captured by discrete morphemes alone. In particular, I will argue that the iconic mapping preserves **geometric structure**, yielding gradient interpretation of gradient phonetic manipulations. Following Emmorey and Herzig, and following discussion in Chapter 5, gradient interpretation can be used as a diagnostic for iconicity.

If indeed there is a measurement-preserving iconic mapping, then why does Wilbur not find any gradient effects? The explanation arises from the fact that the mapping preserves only *relative* measurement, not *absolute* measurement. For example, the form for the verb DIE may be completed in a matter of seconds, yet still denote an event which takes months to elapse. Nevertheless, if two forms of DIE signed at different speeds are brought into comparison, then the slower sign must denote the slower event. What this example illustrates is that, when an event preserves only *relative* information, it is impossible to make any iconic inferences without a standard for comparison.

When a sign is produced in isolation, the only standard for comparison is the default form of the sign (relative to the rate of signing). If a sign is produced in an unexpected way—for example, at a speed that is markedly slower than the overall rate of sign—then it is interpreted in a meaningful way. However, since the default form and canonical meaning are determined by context, the result is an inherently vague interpretation. The situation is familiar from the case of vague adjectives, discussed by Kennedy 2007. In isolation, the adjective *tall* is vague, since the standard for comparison—i.e., what counts as 'tall'—must be inferred from context. In contrast, the sentence '*Ivan is taller than Dmitri*' yields crisp judgments: nothing needs to be taken from context, so half a centimeter difference in height is enough to verify or falsify the sentence.

Wilbur's examples, which look at signs in isolation, can only communicate information about marked or unmarked speed, so are inherently vague. In order to get crisp judgments on gradient forms, it is necessary to provide an overt comparative form.

6.3.3 Gradient iconic manipulations

First, we turn to cases of extended path movement, focusing on paradigms where instances of the same verb are produced at a variety of different speeds.

As it turns out, verbal reduplication provides a conveniently minimal example where many forms of a verb can be put into comparison at once. In ASL (like many other sign languages), a verb can be reduplicated multiple times to express that an event happened again and again. Critically for us, pronunciation of each repetition can vary in speed. When repetitions of the verb are produced at different speeds, the interpretation reflects the difference.

Figure 6.3 presents one attested example from French Sign Language, where the sign for GIVE accelerates from a length of 0.56 seconds down to a length of 0.18 seconds. (In the graph, black bars represent the forward motion of the sign.) The resulting interpretation is that the event occurred at a speed that increased over time. Analogous examples with acceleration and deceleration are also attested in ASL. Critically, the interpretation of acceleration is only possible with more than two levels of speed represented. Wilbur's analysis, with a single [extra] feature, undergenerates.

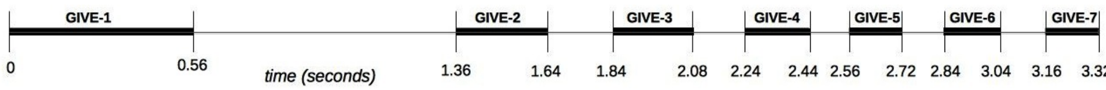


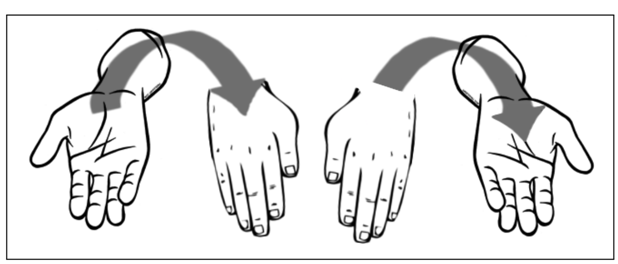
Figure 6.3: Image of accelerating GIVE-rep in LSF

Thus, we conclude that the iconic mapping keeps track of gradient information regarding the relative speed of events. The binary examples reported by Wilbur are the special case that emerge when the only comparison class comes from context.

Next, we turn to rapid deceleration to a stop, as it appears at the end of telic verbs and on incompletive forms. Unlike the speed manipulations above, we observe that rapid deceleration is *not* directly interpreted by the iconic mapping. For example, when the sign ARRIVE is signed slowly, as in (209), it may nevertheless speed up then decelerate immediately before contact. This does not generate the inference that the individual changed their speed right before arrival—it just emphasizes that the individual finally arrived. I thus adopt the insight from Malaia and Wilbur 2012 and Malaia 2014 that rapid deceleration is a cognitively domain-general mechanism for identifying distinguished points of events. I take this to be a separate system that feeds into the iconic mapping described here.

I depart from Wilbur by proposing that these boundary markers can be placed anywhere in the course of the sign and that the iconic mapping is gradiently sensitive to the extent of motion that has transpired by the point of the marker. Final end-marking, then, is just a special case when this marker happens to line up with the end of the path motion. The cases of incompletive forms discussed by Wilbur already suggest that something like this may be the case: stopping the motion of SIT-DOWN at the beginning of the sign produces a different interpretation than stopping the motion at the end of the sign (see above, in (210) and (211)).

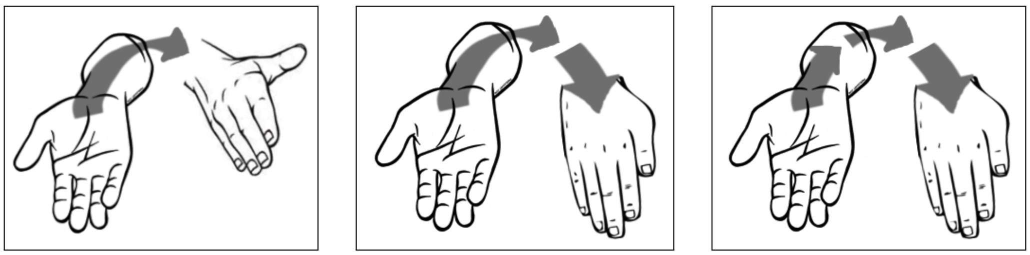
To test the availability of further levels, we turn to examples where motion of the sign stops multiple times during production, generating a 'bit by bit' interpretation. I will construct the argument with the verb DIE in ASL, shown in Figure 6.4: one hand turns palm-up to palm-down as the other turns the opposite direction.



DIE

Figure 6.4: Image of DIE in ASL

As we have seen for SIT-DOWN and ARRIVE, DIE allows motion to be stopped before completion, as in Figure 6.5a, resulting in the interpretation that the subject almost died.[5] However, the motion need not stop completely after this intermediate pause; it may continue to its normal end point, as shown in Figure 6.5b. The resulting inference of this second form is that the subject died, but that the death was interrupted by a period with no decline of health. Finally, the sign DIE can be interrupted by arbitrarily many such pauses, as in Figure 6.5c; the resulting inference of this 'bit-by-bit' inflection is that the subject died gradually, reaching successive states of decreased health until death.



a. 'almost died' b. 'died after a struggle' c. 'gradual death'

Figure 6.5: Iconic modifications of DIE in ASL

What is of note about this final form is that arbitrarily many stops can be included, distributed throughout the production of the sign. In order to get the attested meaning, it must be possible to track different extents of completion of the event. Notably, Figure 6.5c has a distinct meaning from simply reduplicating the incompletive form in 6.5a: a reduplicated 6.5a can mean that health increased in between the points; 6.5c means that the health did not.

Moreover, these intermediate markers are sensitive to fine-grained temporal and spatial modifications. For example, if there are an increased number of pauses as the motion of the sign nears its end point, this is interpreted as meaning that the subject's health declined more and more slowly until the moment of death. In order to capture this meaning, the interpretive system must be able to preserve information from at least two different dimensions: the time elapsed and the distance that the hand has traveled.

Recall that Wilbur's theory predicted that interruptions to a sign should generate only two possible interpretations, depending on location of the attachment ambiguity. What we see here is far more general: there may be arbitrarily many interruptions in a sign; the interpretation of the form is gradiently sensitive to the extent of motion that has transpired at a given point. As before, the examples described by Wilbur are the special cases that emerge when the only standard for comparison comes from context.

[5] For space reasons, the images in Figure 6.5 depict only the motion of the right hand, but the motion of the left hand is parallel.

6.3.4 Summary: iconicity

We have seen that Wilbur's discrete, morphological analysis fails to generate the full range of manipulations that are available in ASL. As an alternative, I have proposed that verbal manipulations are subject to an iconic mapping that preserves information about the form of the sign. This iconic mapping is sensitive to at least two dimensions—namely, the amount of time elapsed at a given point and the distance that the hand has traveled at that point. I have suggested that rapid deceleration is used as a marker to highlight distinguished points in the progression of the event that are sensitive to this mapping.

In the next section, I develop an analysis of change-of-state verbs based on scales that allows us to formalize the iconic mapping. I then turn to telicity, showing how a gradient iconic mapping is able to yield categorical effects.

6.4 Revised view: scales, not states

In §6.2.1, I introduced the fact that a result-state analysis is not viable for degree achievements like *dry* and *close*, based in particular on their variable telicity. I proposed, following Ramchand, that these verbs instead inherit their telicity through properties of an implicit scalar complement.

A recent body of work on the scalar properties of adjectives and verbs flips the perspective (see, e.g., Kennedy and McNally 2005, Kennedy 2007, Kennedy and Levin 2008, Pedersen 2014). Specifically, Kennedy and Levin 2008 propose an analysis in which degree achievements are treated as instantiating the *general case* of verbal telicity. As in Ramchand 2008 (and related theories), verbs are structurally complex; however, for Kennedy and Levin 2008, telic verbs and degree achievements are built from a scale, not from a result state. Telicity arises from the properties of these scales. In particular, inherently telic predicates like *arrive* arise from degenerate scales with only two points.

Scales are defined to be a set of totally-ordered degrees along some dimension (width, dryness, etc.). Together with the lexical meaning of the verb, we are able to associate this set of degrees with a set of states (e.g. the state where x has degree d). In this respect, the scalar analysis is strictly richer than the result-state based analysis; information about a result state is fully recoverable from the scalar component. I will argue that this degree of richness gives us the necessary power to describe the iconic mapping that we have observed in ASL. The iconic representation of closed scales will derive Wilbur's generalization about end-marking and telicity.

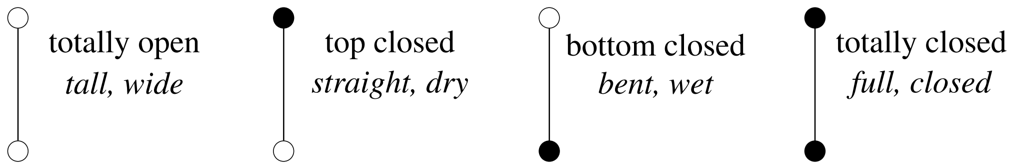
6.4.1 Scales in adjectives

Kennedy and McNally 2005 observe that many adjectives come associated with scales. These scales allow adjectives to show gradability with degree modifiers like *very* (e.g. *very tall*, *very wet*). Constructions like *how*-questions also provide direct reflection of these scales, as their meaning must be stated in terms of an ordered set of points.

(215) a. How large is the box?
b. How wet is the towel?
c. How straight is the path?

A scale, as a totally ordered set, can be characterized by certain mathematical properties. Kennedy and McNally 2005 show that adjectives can be classified by whether their associated scale contains a maximal and/or minimal element (in set terms, a supremum and/or infimum).

(216) Possible structures of gradable adjectives:



Kennedy and McNally 2005 demonstrate that natural language reflects this classification in a variety of ways. For example, some degree-modifiers are only available for scales with certain properties: *slightly* can only modify scales that are closed on bottom (e.g. *slightly wet* vs. **slightly* {*tall*, *dry*}); *completely* can only modify scales that are closed on top (e.g. *completely straight* vs. **completely* {*tall*, *bent*}); *half* can only modify scales that are closed on top and bottom (e.g. *half full* vs. **half* {*tall*, *straight*, *wet*}).

Kennedy 2007 shows that totally open scales display context-sensitivity that is not found for scales that are closed (on either end). The positive form of an adjective based on an open scale receives a relative interpretation; it must be evaluated with respect to a standard of comparison taken from context. For example, something is 'tall' if it has a greater degree of height than some contextually salient standard. In contrast, the positive form of an adjective based on a closed scale receives an absolute interpretation; something is 'wet' if it has greater than zero degree of wetness. Empirically, the relative/absolute distinction can be observed in paradigms with antonyms: if A is not dry, then it is wet, but if B is not wide, it is not necessarily narrow.

Kennedy 2007 proposes that the absolute interpretation of adjectives based on closed scales can be explained through sublexical decomposition and a principle of 'Interpretive Economy.' The essential insights presented below derive from Kennedy 2007, Kennedy and Levin 2008, and Pedersen 2014. However, a number of definitions have been changed from those papers to make synthesis easier and exposition (hopefully) clearer.

We define a measure function to be an additive function that takes an individual x and time t and returns a degree—the measure of x at t. The underlying type of an adjective is a measure function. Thus, the range of the measure function for a given adjective is the scale associated with the adjective—for *wide*, the set of possible widths.

The positive form of an adjective is derived by the application of a function $\mathbf{pos}_A$ to the measure function denoted by the adjective. For a given measure function m, $\mathbf{pos}_A(m)$ checks whether the measure of a particular individual at a particular time is larger than some standard of comparison. This standard of comparison is given by the function **stnd**, which delivers a delineation of a given set with respect to the ordering relation $>$. Specifically, for a given measure function m, the function **stnd** returns a subset of the range of m, delineating the set of degrees into two parts: everything on one side of the delineation is in **stnd**(m), and everything on the other side of it is not. For adjectives, it provides the set of degrees greater than whatever serves as the cut-off for tallness, wetness, straightness, etc.

(217) $\textbf{pos}_A(m) := \lambda xt.m(x)(t) \in \textbf{stnd}(m)$
'Given an individual x and a time t, return true if $m(x)(t)$ is in the set of degrees given by the standard of comparison **stnd**(m).'

Given this definition of $\textbf{pos}_A$, the principle of Interpretive Economy states that, in the determination of **stnd**, context can only be used as a last resort. In the case of relative adjectives, the scale provides no intrinsic points of delineation, so a cut-off must be be taken from context. In the case of absolute adjectives, on the other hand, a closed endpoint of the scale can serve as a point of delineation; because this point is available, Interpretive Economy says that context *cannot* be used. We thus derive the non-context-sensitivity of absolute adjectives.

Figure 6.6 provides an example with *wide* and *dry*. *Wide* has an open scale, so **stnd**(*width*) must come from context. In contrast, *dry* has a top-closed scale, so **stnd**(*dryness*) consists of this maximal degree of dryness.

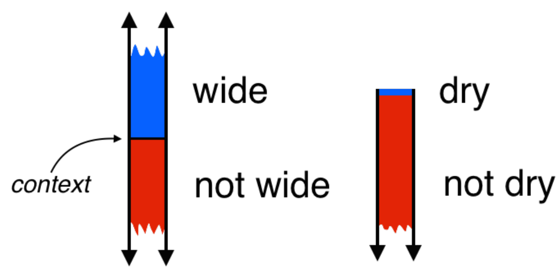


Figure 6.6: Delineation via **stnd** for wide and dry (adjectives).

6.4.2 Scales in verbs

Kennedy and Levin 2008 and Pedersen 2014 argue that a similar decomposition holds for verbs. Motivation for a parallel analysis comes from the observation that verbs are sensitive to the same categories as adjectives. The clearest examples are adjective/verb pairs with an overt morphological connection, like *wide/widen*, *straight/straighten*, *open/open*.

Empirically, a few properties are notable. First, in default contexts, verbs that have an underlying absolute scale generate the inference that the positive form of the adjective comes to hold. Verbs that have an underlying relative scale generate no such inference. This is demonstrated in (218).

(218) a. The towel dried. $\rightarrow$ The towel is now dry.
b. The gap widened. $\not\rightarrow$ The gap is now wide.

Second, the two categories pattern differently with respect to telicity. As we have seen, verbs based on closed scales have a telic and an atelic reading, as in (219). In contrast, verbs based on open scales are always atelic, as seen in (220).

(219) a. The towel dried for an hour.
b. The towel dried in an hour.

(220) a. The gap between the boats widened for a few minutes.
b. ?? The gap between the boats widened in a few minutes.

Kennedy and Levin 2008 and Pedersen 2014 argue that the same basic analysis for adjectives can be extended to verbs with a few modifications. As with adjectives, verb forms are decomposed; however, since verbs denote a change of state, the underlying measure function must be a *pair* of measures: the measure at the beginning of an event and the measure at the end of the event. Thus, for any measure function m, we define the m_Δ as the function that takes an individual and an event, and returns this pair of measures. In the definition below, **start**(e) returns the start time of e; **end**(e) returns the end time of e.

(221) For any measure function m,
$m_\Delta := \lambda ex.\langle \quad m(x)(\textbf{start}(e)) \ , \ m(x)(\textbf{end}(e)) \quad \rangle$

Pedersen 2014 proposes that positive verbal forms can be derived in a way completely analogous to the positive adjectival forms, by checking whether the change of degree of an individual x over an event e is in the relevant standard-of-comparison set. A definition of $\textbf{pos}_V$ is provided in (222).

(222) $\textbf{pos}_V(m_\Delta) := \lambda xe.m_\Delta(x)(e) \in \textbf{stnd}(m_\Delta)$
'Given an individual x and an event e, return true if $m_\Delta(x)(e)$ is in the set of degrees given by the standard of comparison $\textbf{stnd}(m_\Delta)$.'

Pedersen 2014 observes that something interesting happens with respect to the delineation function **stnd** when it applies to verbs based on open scales. In the case of adjectives, we saw that open-scales provided no intrinsic point of delineation, so a relative adjective was forced to use a cut-off point from context. In the case of verbs, however, **stnd** takes as its input a set of *pairs* of degrees. Since **stnd** is sensitive to the ordering relation $>$, this means that the ordering relation *itself* can serve as the point of delineation across this two-dimensional set: the standard-of-comparison set includes any event with positive change along the scale. Figure 6.7 provides an example with the verb *widen*.
Because an intrinsic delineation can be found for verbs based on relative scales, Interpretive Economy says that context cannot be used. There is thus no inference that the positive form of the adjective holds, deriving the observation in (218b).

In fact, this delineation is available to any verb of change, including verbs derived from closed scales. In the case of verbs derived from closed scales, however, the closed endpoint of the scale can can also serve as a point of delineation with no cost from Interpretive Economy.

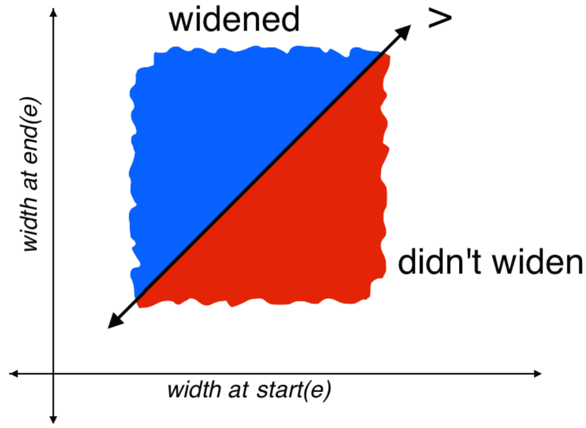


Figure 6.7: Delineation via **stnd** for widen (verb).

The result is that two delineations are possible, and the verbs are ambiguous between two logical forms.

The two delineations for the verb *dry* are shown in Figure 6.8. The resulting readings are given in (223).

(223) a. There exists degrees d_1 and d_2 such that there is monotonic change in dryness from d_1 to d_2 and $d_2 > d_1$.

b. There exists degrees d_1 and d_2 such that there is monotonic change in dryness from d_1 to d_2 and $d_2 > d_1$ $\underline{\text{and } d_2 = \max(\textit{dry})}$.

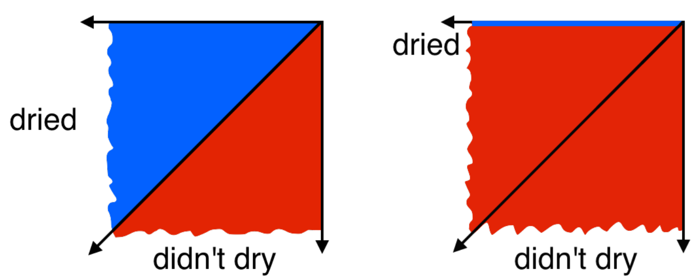


Figure 6.8: Ambiguous delineation via **stnd** for dry (verbs).

At this point, Kennedy and Levin 2008 propose that standard pragmatic reasoning kicks in: the two forms in (223) are in competition, so the more informative form is chosen. The form in (223b), which includes the condition that the maximum standard was reached, is strictly stronger. Thus, in standard cases, a sentence with a closed scale will generate the inference that the positive form of the adjective holds, deriving the observation in (218a).

But, since this is an ordinary implicature, it can disappear or be canceled; for example, it is the interpretation in (223a) that appears in *for*-adverbials (as in 219a), where there is no inference that a maximal degree was reached.

Finally, we can explain the facts about telicity by observing that the two meanings in (223) differ with respect to Stratified Reference. Specifically, if there is an event of monotonic change between some two points, then any subevent will also be an instance of monotonic change between two points. Thus, the meaning in (223a) has Stratified Reference. This is the only reading available for verbs with open scales, so these verbs are necessarily atelic, deriving the observation in (220).

On the other hand, if the value of one of these two points is specified, as in (223b), this will not be the case: no subevent that doesn't include that point will be able to satisfy the predicate. Thus, the meaning in (223a) does not have Stratified Reference. Both readings in (223) are available to verbs based on closed scales, so these verbs may be either telic or atelic, deriving the observation in (219).

6.4.3 Degenerate scales

The analysis of verbs as being associated with scales works very well for scalar verbs like *open*, *widen*, and *dry*, but doesn't immediately seem to carry over to predicates that seem to denote binary changes like *die*, *enter*, and *awaken*.

Rappaport Hovav 2008, and Kennedy and Levin 2008 show that there is in fact no fundamental problem for these cases; verbs of binary change are simply represented as a degenerate scale consisting of two points—for example, the verb *appear* consists of the two points 'not there' and 'there.' With only two points, these scales are necessarily top- and bottom-closed, so yield telic events.

In §6.5.2, I return to the case of degenerate scales in ASL. I show that many degenerate scales can be coerced into full scales by iconic modifications, providing motivation for this unified analysis.

6.5 Iconic scales

I propose that phonological path movement iconically represents the scale associated with a change-of-state verb in ASL.[6]

The claim that scales can be iconically represented in sign language has been argued independently by Aristodemo and Geraci 2015 for adjectives in Italian Sign Language (LIS). They show that when the phonological form of an adjective includes a path motion, a comparative form can be constructed by signing the adjective at two different positions along the path motion. For example, in both LIS and ASL, the adjective TALL is signed with a bent flat hand held at some height in front of the speaker. The same sign can then be repeated at a higher

[6] It may turn out that verbs iconically represent even *more* information than just the scale associated with a verb. For example, Philippe Schlenker (p.c.) reports gradient judgments for paradigms involving the sign HIT-MISS 'tried to hit but missed,' where the distance by which the hit was missed is gradiently interpreted depending on the distance between the two hands. What is necessary for the current analysis is that the iconically represented scale that I describe here is *available*, either as a primitive in itself or as derived from a more general iconic mapping.

height to indicate that a second individual is taller than the first. The distance between the two phonological forms is interpreted to indicate the relative degree of difference in the two heights. Aristodemo and Geraci 2015 demonstrate that an analogous pattern holds across a wide range of gradable adjectives, including ones involving abstract scales like CULTIVATED.[7]

(224) **Italian Sign Language** (from Aristodemo and Geraci 2015)
MARIA TALL-x GIANNI TALL-scale-more-y.
'Gianni is taller than Maria.'

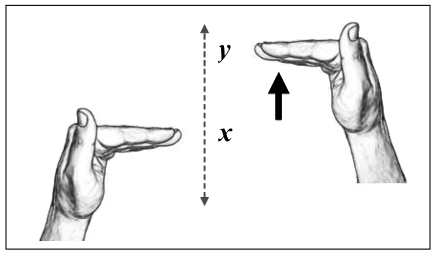


Figure 6.9: Images of 'TALL-x' and 'TALL-scale-more-y' in a comparative construction in LIS. The vertical dimension iconically represents the height scale.

As discussed in §6.4, scales may be open or closed at either end; Aristodemo and Geraci show that closed scales may be iconically represented in LIS and LSF (French Sign Language) by phonetic motions that are bounded on one end by contact of the dominant hand with another part of the body. For example, the adjective FULL in LIS is signed by making contact between the two hands; the result is that the adjective lacks the imprecision that generally characterizes gradable adjectives. Like the closed scale it represents, the hand literally can't move any further along the phonological path movement.

6.5.1 Iconic scales on verbs

I propose that the same scales that are iconically represented in adjectives are also iconically represented in change-of-state verbs in ASL. As discussed in §6.4, the same scale may form the semantic core of both an adjectival form and a verbal form, generating pairs like *wide* and *widen* in English. In ASL, similar pairs can be found, differing only in their phonological movement. For example, TALL in ASL is signed with bent hand and a small forward movement; the sign for GROW-UP in ASL is identical, except that the hand moves in a straight, upwards movement.

Notably, the scale that forms the basis of both the adjective and verb is iconically represented in both phonological forms. In the case of the verb, movement along this scale is represented as movement along the phonological path. An analogous pattern can be seen with the adjective

[7]Note that these scales need not always be iconically instantiated; for example, the scale associated with *smart* is no more abstract than the scale associated with *cultivated*, but SMART in LIS does not have the necessary phonological form to represent a scale.

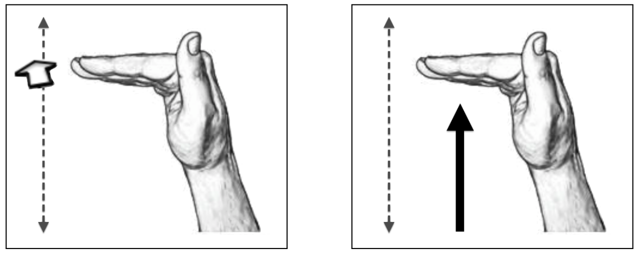


Figure 6.10: Images of TALL and GROW-UP in ASL.

BIG, and the verbs GET-BIGGER (with a movement outwards) and SHRINK (with a movement inwards).

If scales are iconically represented in verbal forms, then the gradient manipulations described in §6.3.3 can be explained as an iconic mapping that preserves both scale structure of the event (as represented by distance along the phonological path movement) and time-course of the event (as represented by the time-course of the phonetic motion). End-marking on telic verbs is the iconic representation of the end of a closed scale.

More precisely, for each point in the production of a verb, we say that (a) the time that has elapsed after the onset of the sign is proportional to the time that has elapsed after the start of event, and that (b) the distance that has been traversed from the beginning of the phonetic motion is proportional to the degree that the measure has changed from the initiation of the event.

We state these two conditions formally in what follows. Given a verb V, let Φ be a phonetic form of V, and let e be an event in its denotation.

First, we define a relation **sync** that corresponds the time-course of Φ with the time-course of e. For any time t_Φ in the pronunciation of the verb and any time t_e in the runtime in of an event, we say that $\textbf{sync}(t_\Phi, t_e)$ (read: 't_Φ is synced with t_e') iff the same percentage of time has elapsed in the runtime of the event at t_e as has elapsed in the runtime of the pronunciation at t_Φ.

In the definition below, $\textbf{start}(e)$ returns the start time of e; $\textbf{end}(e)$ returns the end time of e. In the phonetic domain, $\textbf{onset}(\Phi)$ returns the start time of Φ; $\textbf{coda}(\Phi)$ returns the end time of Φ. I use different function names to stress that the former two deal with conceptual space and the latter two are measurements of the phonetic form.

(225) **Definition:**

$$\textbf{sync}(t_\Phi, t_e) \quad \Leftrightarrow \quad \frac{t_e - \textbf{start}(e)}{\textbf{end}(e) - \textbf{start}(e)} = \frac{t_\Phi - \textbf{onset}(\Phi)}{\textbf{coda}(\Phi) - \textbf{onset}(\Phi)}$$

Second, we posit an iconic condition that corresponds the distance that the phonetic form has traveled at time t_Φ with the degree that the measure has changed in the event at a synced time t_e. Namely, if t_Φ is synced with t_e, then the percentage of measurement that has changed at point t_e (relative to a complete event) is equal to the percentage of distance that has been crossed at point t_Φ (relative to a complete sign).

In the definition below, $m(x)(t)$ returns the measurement of x at time t; $d(t)$ returns the distance that the hand has traveled at time t. The event e_0 is a canonical event of V in which x_0 is the participant that changes in measure; Φ_0 is a default pronunciation of V.

(226) **Iconic condition on scalar change:**

$$\forall t_\Phi, t_e.\textbf{sync}(t_\Phi, t_e) \rightarrow$$
$$\frac{m(x)(t_e) - m(x_0)(\textbf{start}(e_0))}{m(x_0)(\textbf{end}(e_0)) - m(x_0)(\textbf{start}(e_0))} = \frac{d(t_\Phi) - d(\textbf{onset}(\Phi_0))}{d(\textbf{coda}(\Phi_0)) - d(\textbf{onset}(\Phi_0))}$$

Comparison to a default, canonical phonological form allows us a way to formulate what's going on in incompletive constructions: in order to know that a phonetic form is incomplete, we must know what the particular phonetic form was, but also *how it is normally signed*.

Finally, to formally represent the fact that end-marking on verbs is the end of a closed scale, we state the condition that if a phonological motion at t_Φ reaches the maximal distance it can travel (perhaps due to contact with another part of the body), then the measure of an individual at t_e synced with t_Φ is the maximal measure on a scale.

(227) **Iconic condition on scalar endpoints:**

$$\forall t_\Phi, t_e.\textbf{sync}(t_\Phi, t_e) \quad \rightarrow \quad [d(t_\Phi) = \max(d) \rightarrow m(x)(t_e) = \max(m)]$$

Essentially, what the conditions above say is that the graph of relative measure-over-time for the event e matches the graph of relative distance-over-time for the phonetic form Φ. For example, Figure 6.11 shows a possible graph of a phonetic form that starts out fast then decelerates, and never is completed (it never reaches 100% distance of the canonical form.) The same graph shows the event progression of the event denoted by the verb form.

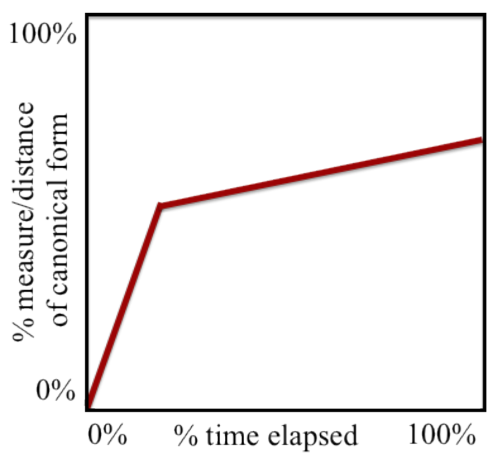


Figure 6.11: Event progression/phonetic form of a decelerating incompletive form.

One final revision is needed of this iconic mapping; namely, as we saw earlier, sharp decelerations may be used to segment distinguished points of an event without being interpreted literally as decelerations in the speed at which the event happens. To capture this observation, we will weaken the iconic condition in (226): instead of quantifying over all t_Φ, t_e, we quantify only over distinguished points of the phonetic form. One way of distinguishing points is to use sharp decelerations.

6.5.2 Degenerate scales in ASL

In §6.4.3, I suggested, following Rappaport Hovav 2008 and Kennedy and Levin 2008, that inherently telic predicates arise from degenerate, two-point scales, as opposed to arising from an unrelated mechanism (such as a *res* morpheme).

The ASL data seems to support the analysis that unites verbs of binary change with scalar verbs. In particular, iconic manipulations can easily coerce a scale that is otherwise binary into a more fine-grained scale. For example, the scale underlying *die* contains only two points, 'dead' and 'not dead.' As we have seen, though, on the iconic manipulations of DIE in Figure 6.5, the binary predicate is coerced into one denoting change along a scale.

As is perhaps expected, the ease with which this coercion can happen depends on how easy it is to accommodate a gradient scale for a particular verb meaning. For example, the verb *die* can easily be associated with a scale measuring health that is closed at the bottom by death (a state of zero health); in contrast, it is not as clear what non-binary scale can be associated with the verb *notice*.

These differences are reflected in grammaticality judgments of iconic manipulations of different verbs. For example, DIE-bit-by-bit (as shown in Figure 6.5c) is perfectly acceptable; similarly, the verbs CHANGE (as in 'a friend's face changed') and ARRIVE are perfectly acceptable with 'bit-by-bit' inflection, which entails the existence of successive intermediate stages of the event. In contrast, other telic verbs receive degraded judgments with 'bit-by-bit' inflection. On a seven-point scale (7=best), NOTICE-bit-by-bit receives an average rating of 2/7; BUY-bit-by-bit receives a rating of 3.7/7.

In the cases where a gradient scale cannot be coerced, many iconic manipulations become unavailable. The result is that the manipulations that remain possible in many cases approximate the typologies discussed by Wilbur. However, this correspondence is not exact; for example, both NOTICE and BUY also receive a degraded judgment (3/7 and 4.3/7 respectively) when signed with a slow, extended path movement. Wilbur has no explanation why [extra] couldn't apply here. In contrast, the iconic analysis makes the correct prediction that extended path motion should be available to an extent closely correlated with the availability of 'bit-by-bit' inflection, determined by the ease of coercing the relevant scale.

6.5.3 Deriving telicity in ASL

At this point, deriving the telicity of end-marked predicates in ASL is completely straightforward: when a verbal form travels the maximal distance that the phonological motion can travel, the iconic condition on endpoints in (227) entails that a scalar change reaches a maximal degree in every event in the denotation of the verb (in the terms above, that $m(x)(\mathbf{end}(e)) = \mathbf{max}(m)$).

This in turn means that the predicate is telic. The reasoning is exactly as we saw before: given an event e in the denotation of the predicate, any sub-event over an interval that doesn't include $\mathbf{end}(e)$ will not include the maximal degree, so will not be in the denotation of the predicate. Thus, the predicate cannot be exhaustively divided into temporally small events of which the predicate holds. The predicate does not have Stratified Reference, so is telic.

The connection to the telicity of predicates in English is slightly more indirect. The key observation is that the iconic condition on endpoints is only defined if $\mathbf{max}(m)$ exists—that is, if the meaning of the verb is based on a closed scale. As we saw in §6.4.2, verbs based on closed scales are exactly those verbs which default to telic meanings, though pragmatic reasoning governing the choice of **stnd**. Thus, the endpoint of a verb may only be iconically marked in ASL if it corresponds to a verb meaning that would be interpreted as telic in English as well.

6.6 Conclusions and extensions

6.6.1 Extension: *again*-ambiguities

One further extension should be flagged as an area for further research. In English, the adverb *again* has been shown to be ambiguous between a repetitive reading and a restitutive reading. For example, the sentence in (228) has two possible interpretations (neither of which entails the other), differing in their presuppositions: the first presupposes that a certain event previously occurred; the second presupposes a certain state previously held.

(228) The river widened again.
   a. It widened twice (perhaps incrementally).
   b. It widened to a former size.

Traditional analyses of *again*-ambiguities (e.g. von Stechow 1996) have captured them via an attachment ambiguity on a verbal decomposition containing a result state, parallel to what we saw for *almost*, as in (213). Pedersen 2014 argues, based largely on facts regarding degree achievements like the example in (228), that a more unified picture of *again*-ambiguities emerges if we posit a verbal decomposition containing a scale, as discussed in §6.4.2.

It turns out that ASL brings interesting data to the table in this domain as well. ASL, like English (and various other languages), shows ambiguities with AGAIN; the examples in (229) can each be shown to have two readings, analogous to the readings of the English glosses that I have given.

(229) a. ME DOOR AGAIN CLOSE.
   'I closed the door again.'
   b. YESTERDAY JOHN SELF CHANGE WOLF AGAIN
   'Yesterday, John changed into a wolf again.'

c. THIS YEAR, GROUP AGAIN GREW.
'This year, my group grew again.'

d. THIS WEEK, TEMPERATURE INCREASE AGAIN.
'This week, the temperature increased again.'

In ASL, however, an interesting situation emerges when AGAIN is used with iconically incompletive verbs. Specifically, preliminary results suggest that when AGAIN modifies an incompletive form like CLOSE-incomplete, two readings are still available. On the repetitive reading, the sentence presupposes that the speaker incompletely closed the door previously. Interestingly, a restitutive reading also exists, and presupposes that the door was previously in a state *of being incompletely closed*. Note that this is not a possible reading of the English sentence '*I almost closed the door again*' (which nevertheless has about five other readings).

(230) I DOOR AGAIN CLOSE-incomplete.

(231) Possible presuppositions:

a. **Repetitive:** I incompletely closed the door before.

b. **Restitutive:** The door was incompletely closed before.

The availability of the restitutive reading in (231b) shows that the state of incomplete closure must be retrievable from the meaning of the modified verb so that it can be targeted by *again*. On a state-based decompositional analysis, no such state exists, since the only sub-tree available is the result state denoting full closure. In contrast, a scale-based decompositional analysis provides access to the full set of closures. The state of incomplete closure can be made available, provided that it is made sufficiently salient, like, for example, through by the sharp stop associated with the incompletive form.

I leave further empirical and theoretical investigation for future research.

6.6.2 Conclusions

In this chapter, I addressed two observations from Wilbur 2003, 2008, and 2009: first, that certain properties of a verb's phonetic form are correlated with the telicity of the verb; second, that phonetic manipulations of a verb may be semantically interpreted. I argued that the purely morphological system proposed by Wilbur is not sufficient to capture the full range of manipulations that are possible in ASL. As an alternative, I advocated a theory in which an iconic mapping preserves information about timing and event progression. I showed that this iconic mapping could be formalized if we adopted recent theories (Kennedy and Levin 2008, Pedersen 2014) in which verbal telicity arises from the properties of associated scales.

I argued that the phonetic marking of telicity in ASL arises from the iconic marking of the maximum degree on a closed scale. This analysis presented a clear natural class of phonetically end-marked telic verbs in ASL, including both telic degree achievements like CLOSE and verbs based on degenerate scales like ARRIVE. A unified analysis of the two was also supported by the ability to iconically coerce some verbs of the latter category into forms with richer scale structures.

It should be noted that the analysis that I have advocated shares certain important features of Wilbur's analysis. First, I have posited that verbs are structurally complex, and that various syntactic and semantic properties of a verb emerge from properties of its sub-lexical decomposition. Second, I maintain the insight from Malaia and Wilbur 2012 and Malaia 2014 that rapid deceleration is a general cognitive mechanism for event segmentation.

The analysis presented here, however, puts iconicity front and center, not only as a grounding for discrete morphemes, but as active component of a synchronic form.

Chapter 7

Pluractionality and iconicity in French Sign Language

This chapter is coauthored with Valentina Aristodemo.[1]

7.1 Overview

This chapter contributes to recent discussions about the interaction of iconicity and formal grammar in sign languages. We will be focusing on a case study of pluractionality in French Sign Language (Langue des Signes Française, LSF).

For the last forty years, there has been a large amount of descriptive work on verbal inflection in sign languages (Fischer 1973, Klima and Bellugi 1979). The basic finding is that, by repeating a verb form in a variety of different ways, a variety of different meanings can be communicated. Proposed distinct readings include iterative, habitual, incessant, and durative forms, among others. Wilbur 2009 proposes a decompositional analysis of these forms, proposing that the range of meanings arise from combinations of a finite set of morphemes.

Example (232) provides a specific example of an inflected verb in context.[2]

(232) OFTEN ONE PERSON FORGET-rep ONE WORD
‘Often, one person forgets one word.’

The verb FORGET is signed with a single hand in front of the forehead. In (232), the motion is repeated several times with the same hand. The resulting meaning is that a person kept on forgetting a word.

In this chapter, we will argue that there is a categorial semantic difference between two pluractional forms that we will look at: the first is a full one-handed repetition of the sign (as

[1]Note on coauthorship: both authors conducted the field work and developed the theoretical analysis. The chapter was written by Jeremy Kuhn.

[2]Note on glossing conventions: Although LSF is used in areas where spoken French is a contact language, we will gloss signs with their closest *English* translation.

above in (232)); the second is an alternating two-handed repetition of the sign. We will see that the distributive semantics of these two forms fit into a large pattern of pluractionality across spoken languages.

Additionally, though, we will argue that there is an iconic component to both of these forms. We will use an argument from gradient interpretation. This will be a more abstract case of iconicity than some other cases of iconicity that have been discussed in the literature (Liddell 2003, Emmorey and Herzig 2003, Schlenker, Lamberton, and Santoro 2013), because the iconic mapping relates to verbal events instead of (pro)nominal objects.

Section 7.4 will combine these two observations into a single system. The initial implementation will be completely straightforward, following insights from Schlenker, Lamberton, and Santoro 2013. Of note, though, the resulting system will be expressively more powerful than what is commonly assumed for spoken language under standard assumptions of generative grammar.

7.2 Pluractionality

In many languages of the world, verbs may show pluractional inflection; often this is indicated by reduplication. The general idea is that these communicate that there is a multitude of events: either an event happened again and again, or many things happened at the same time.

Table (233) gives some examples of pluractional inflection via reduplication, to show that the phonological process in sign language fits into a larger pattern.

(233)
a. **Hausa:** kiraa → kirkiraa — 'keep on calling'/'call many people'
b. **Pomo:** quo → quoquot — 'cough up'
c. **Dyirbal:** balgan → balbalgan — 'hit too much'
d. **Yokuts:** simwiyi → simimwiyi — 'keep on drizzling'

(P. Newman 2012, Moshinsky 1974, Dixon 1972, S. Newman 1944)

Semantically, what do these forms mean? Sentence (234) provides an example from Upriver Halkomelem (Thompson 2009). The verb /yáq/ means 'to fell'. With the pluractional inflection, /yáleq'/, this can be used to describe a range of different contexts: it can mean that multiple people felled a tree; it can mean that one person felled multiple trees; it can mean that one person felled one (magical) tree again and again. What it *can't* mean is that one person felled one tree one time.

(234) **Upriver Halkomelem** (Thompson 2009)

yáleq' -et -es te theqát (cf. yáq'-et)
fall.pl -tr. -3 det. tree

(235) True if ...

a. He felled the trees. (all in one blow, or one after the other)

b. He felled the same (magic) tree over and over.

c. They felled the tree.

d. They felled the trees.

False if ...

e. He felled the tree (once).

Figure 7.1 provide pictures to illustrate the range of meanings. Along the y-axis, θ indicates participants; time is along the x-axis. So, Figure 7.1a depicts a repeating event, as in (235b); Figure 7.1b depicts the multi-participant contexts in (235a), (235c) and (235d); Figure 7.1c depicts the singular event in (235e). What it means to be pluractional is that the picture has more than one line.

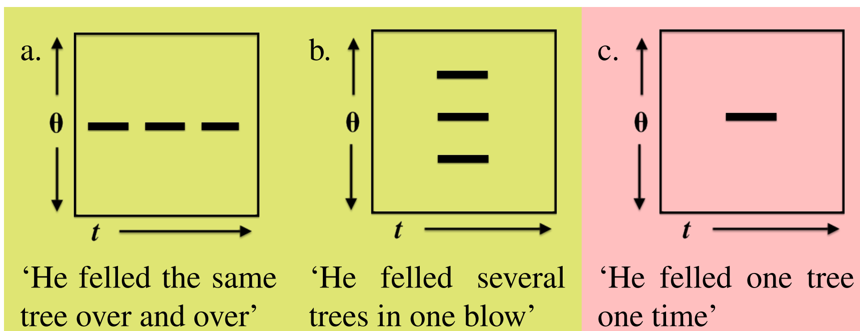


Figure 7.1: Different kinds of events; green outlines pluractional events.

Cross-linguistically, Cusic 1981 shows that the range of meanings of pluractional markers is subject to variation across several parameters, including, most relevantly here, a distributive parameter, which specifies the dimension over which the plurality of events may be distributed. As we have seen, the pluractional marker in Upriver Halkomelem is compatible with events which are distributed over either time or participants; however, pluractional markers in other languages may require distribution over a specific dimension, allowing only the interpretation depicted by Figure 7.1a or the interpretation depicted by Figure 7.1b. Another dimension across events which can be distributed is location (though this will be less relevant for the LSF data).

The following sentences provide examples from two languages. In ǂHoan (Collins 2001), the pluractional inflection *kí*-VERB-*q‖o* requires distribution over space; in (236) the inflected verb *kí'amq‖o*, 'eat around,' must be interpreted as denoting eating events at different places (evidenced by incompatibility with the continuation 'in one place'). In West Greenlandic (Van Geenhoven 2004), the affix *-tar-* requires distribution over time; in (237), the inflected verb *saniuqquttarpuq*, 'go by repeatedly,' must be interpreted as denoting an event that occurred repeatedly, as in Figure 7.1a.

(236) **ǂHoan** (Collins 2001, via Hofherr & Laca 2012)

titi i- kí-'am-q‖o *(ki ci m⊙un)
Titi PAST pl-eat-around *(PREP place one)

'Titi eats around *(in one place).'

(237) **West Greenlandic** (Van Geenhoven 2004, via Hofherr & Laca 2012)

Nuka ullaa-p tunga-a tama-at saniuqqut-tar-puq.
Nuka morning-Erg direction-Sg.Sg.Abs all-3Sg go.by-repeatedly-Ind.[–Tr].3Sg

'Nuka went by repeatedly for the whole morning.'

Furthermore, a single language can sometimes have several pluractional markers that distribute across different dimensions. For example, Faller 2012 reports that Cuzco Quechua has at least six pluractional morphemes indicating a plurality of events: /-raya/, /-nya/, /-paya/, /-kacha/, /-na/, /-pa/. These six pluractional morphemes specify different dimensions over which these events can be distributed; for example, while /-na/ allows distribution over either time or participants (Figure 7.1a or b), /-raya/ requires distribution over time (Figure 7.1a).

7.2.1 Pluractionality in English

In the typology of pluractionality, English is probably one of the most boring languages to study; nevertheless, there are a few constructions that seem to produce pluractional meanings. We will spend some time on these now, both because there are a few interesting differences which have until now been unremarked in the literature, and because it will allow us to introduce new methodological tools that will be used in the semantic description of the pluractional forms in LSF.

In English, there are several constructions that entail that a plurality of events are distributed over time. These include auxiliary modification (in (238a)), adverbial modification (in (238b)), and verbal conjunction (in (238c)).

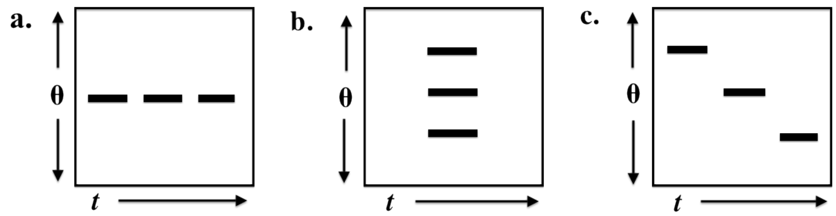
(238) a. John kept coughing.
b. John coughed repeatedly.
c. John coughed and coughed.

Comparing the forms in (238), one is hard-pressed to give hard-and-fast truth-conditional differences between the meanings. Each sentence is true if John coughed multiple times, spread over time.

As it turns out, though, these forms act slightly differently when combined with a plural subject—thus allowing the possibility of distribution over participants. For each construction, there must still be distribution over time. However, there is a difference in whether the plurality of events is *able* to additionally vary with respect to participants. For example, consider a scenario in which each of my friends coughed a single time, but these single coughs were spread out over a length of time. This scenario could be described by sentence (239a), but not (239b) or (239c). The range of potential meanings are illustrated in (240).

(239) a. My friends kept coughing. ✓(240a) *(240b) ✓(240c)
b. My friends coughed repeatedly. ✓(240a) *(240b) *(240c)

c. My friends coughed again and again. ✓(240a) *(240b) *(240c)

(240) 

This contrast becomes very striking with change-of-state verbs, which are weird with repetitive meanings. To illustrate this, consider the sentences in (241).

(241) a. # John kept leaving the party.
b. # John left the party repeatedly.
c. # John left the party again and again.

Although the sentences in (241) are perfectly well-formed syntactically, there is something bizarrely contradictory about the a repetitive meaning with 'left': once one has already left, one can't leave again. (Possibly a context could be constructed where this could be used, but it requires quite a bit of work.)

This fact brings out the contrast in the English pluractional constructions, by turning interpretation judgments into acceptability judgments. Sentence (242a) is perfectly fine, referring to a scenario where the friends left one by one; in contrast, (242b) and (c) retain the bizarreness of the sentences in (241).

(242) a. My friends kept leaving the party.
b. # My friends left the party repeatedly.
c. # My friends left the party again and again.

(As before, it may be possible to envision a context to satsify (242b) and (c), but this should be exactly as hard as it is for the sentences in (241).)

These contrasts are even stronger with the verb *die*, as in (243).

(243) a. My friends keep dying.
b. # My friends die repeatedly.
c. # My friends die again and again.
d. ? My friends die and die.

Hofherr & Laca 2012 show that similar paradigms can be found for pluractional morphemes in other languages. For example, in (236), we saw that the pluractional verb *kí'amq‖o* ('eat around') in ǂHoan necessarily distributes events over locations. Collins 2001 shows that these events *cannot* differ in their participants. For example, Collins 2001 reports that the sentence in (244) is not satisfied if, e.g., Chris ate in one place, Titi ate in another place and Leha ate in a third place; they each must eat in different places; either together or separately.

(244) **ǂHoan** (Collins 2001)

tsi i kí-'am-q‖o.
3Pl PAST pl-eat-around

'They ate around.'

Thus, the representations in (240) provide another possible locus of variation. In cases of temporal pluractionals, we have seen that change-of-state verbs provide a clear test for the availability of these meanings.

7.2.2 Pluractionality in LSF

In LSF as well, verbs may be inflected with reduplication to indicate pluractionality. We will be focusing on two different morphemes which appear across a wide range of verbs. The first we will call /-rep/ for 'repeat': this is full repetition of the exact same motion of the verb. The second, which we will call /-alt/, is alternating motion of the two hands. The sign for FORGET is shown in Figure 7.2. Inflection of FORGET with /-rep/ is shown in Figure 7.3. Inflection of FORGET with /-alt/ is shown in Figure 7.4.

Figure 7.2: Picture of FORGET

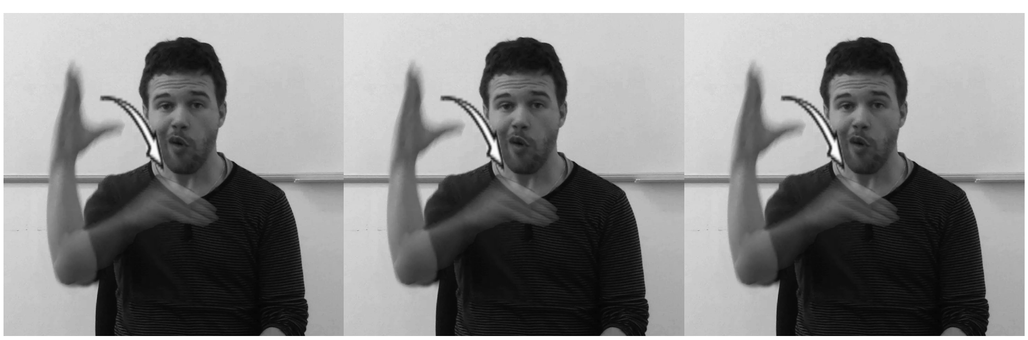


Figure 7.3: Picture of FORGET-rep

Figure 7.4: Picture of FORGET-alt

These two inflections appear productively across a wide range of verbs, including agreeing and non-agreeing verbs and verbs of a variety of phonological forms (including two-handed signs like ARRIVE). Note that since these forms appear on both agreeing and non-agreeing verbs, the effects that we will see here cannot be attributed solely to interactions with plural marking in the nominal domain.

So, what do these forms mean? Roughly speaking, FORGET-rep means 'forget again and again'; FORGET-alt means 'forget many things' or 'many people forget'. In other words, these are exactly the same dimensions of pluractionality that we saw in the spoken language typology earlier: /-alt/ and /-rep/ just carve up the space of pluractional meanings along specific dimensions. In the following subsections, we motivate these claims, and hone in on more precise denotations for the two forms.

7.2.3 /alt/: distribution over participants

/-alt/ can be licensed by a plural in any argument position. So, (245), in which the subject is plural, is grammatical with /-alt/; (246), in which the direct object is plural, is also grammatical with /-alt/.

(245) GROUP PEOPLE BOOK GIVE-1-alt **pl. agent**
'A group of people gave me books.'

(246) ONE PERSON FORGET-alt SEVERAL WORDS **pl. theme**
'One person forgot several words.'

In contrast, (247), minimally different from (246), is not grammatical with /-alt/.

(247) * ONE PERSON FORGET-alt ONE WORD
Intended: 'One person forgot one word.'

Sentences (245)–(246) are compatible with events spread over time. However, distribution over time alone is not sufficient for /-alt/. For example, (248) is ungrammatical even with the presence of the word 'often', which (when grammatical) entails that there is a plurality of events distributed over time.

(248) * OFTEN ONE PERSON FORGET-alt ONE WORD
Intended: 'One person often forgot one word.'

In sum, /-alt/ entails that a plurality of events vary with respect to their thematic arguments; the presence of a plural argument is therefore necessary to license the presence of /-alt/.

7.2.4 /rep/: distribution over time

In contrast, /-rep/ does the opposite; /-rep/ requires distribution over time.

Sentence (249), minimally different from (247)/(248), is grammatical. The sentence is grammatical even without the overt temporal adverbial OFTEN, and still communicates that the event repeated.

(249) (OFTEN) ONE PERSON FORGET-rep ONE WORD
'One person often forgot one word.'

In fact, slightly more fine-grained judgments show that /-rep/ actually *requires* that the participants be the same in each sub-event. For example, (250) has a plural subject occurring with /-rep/; as we saw in the discussion of English in §7.2.1, a situation in which a different friend forgot a camera on each day would be a situation that has distribution over time *and* participants.

In order to judge the availability of this meaning, the subject was asked to do a situation matching task: could the sentence be used to describe each of several situations, described in LSF. The finding is that the sentence has to mean that the group *as a whole* is forgetting a camera each time. Specifically, it cannot be used in a context in which John forgot a camera on Monday, Mary forgot a camera on Tuesday, and Bill forgot a camera on Wednesday; reading (250c) is not available.

(250) MY FRIENDS CL-area FORGOT-rep BRING CAMERA
'My friends forgot to bring a camera again and again.'

a. ✓ several times; each time, all forgot
b. * a single time; all forgot
c. * several times; each time, a different one forgot

For English, we saw that creating paradigms with change-of-state verbs allowed us to turn context-matching tasks into acceptability tasks. In LSF, exactly the same test can be constructed to probe the possible readings of /-rep/; we find that, like English 'repeatedly' and 'again and again,' /-rep/ is bizarre with the verb 'leave,' demonstrating that each event must involve the same participants.

(251) a. # MY FRIENDS LEFT-rep.
b. MY FRIENDS LEFT-alt.

Thus, /-rep/ must distribute events across time, and cannot distribute them across participants.

7.2.5 Generalizations: /-alt/ and /-rep/

Figure 7.5 provides pictures to illustrate the descriptive generalizations. On the left, /-rep/ denotes events which are distributed over time, but have the same participants. On the right, /-alt/ denotes events which must vary over the participants (so is only licensed by a plural argument), and which can optionally vary over time.

	/-rep/	/-alt/
a. distribution over only time	✓	*
b. distribution over only participants	*	✓
c. distribution over participants and time	*	✓

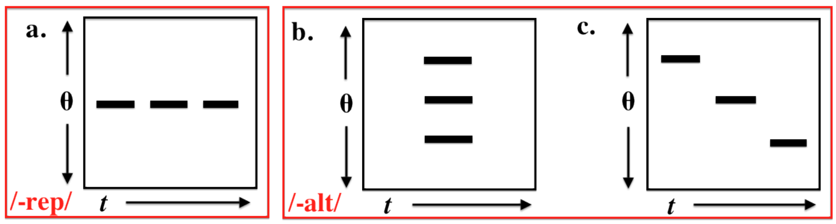


Figure 7.5: Summary of available readings with /-rep/ and /-alt/

To describe these truth conditions, we will adopt a neo-Davidsonian event semantics, where verbs denote sets of events (e.g., Davidson 1967, Carlson 1984). Verbal arguments are related to events through thematic role functions; thus if e is an event witnessing the fact that John coughed, then agent(e) = John. Events form a mereological structure; $\preceq$ indicates mereological parthood ($e' \preceq e$ is read "e' is part of e").

Formally, (252) provides definitions, adapted from a similar analysis in Lasersohn 1995. Here, $^*V$ denotes the algebraic closure of an event denotation V under sum formation, creating the set of all singular and plural V-ing events. The function $|\cdot|$ measures the cardinality of atoms in a sum individual; $>$ compares numerical values (standard "greater than"). We let $\theta(e)$ be the tuple of the arguments of an event: $\langle$agent(e),theme$(e), ...\rangle$.

(252) a. $[\![\text{-alt}]\!] = \lambda V.\lambda e[e \in {}^*V \ \wedge \ |e| > 1 \ \wedge \ \exists e', e'' \preceq e[\theta(e') \neq \theta(e'')]]$
'/-alt/ takes a verb V and gives the set of plural V-ing events that have at least two subparts with different thematic arguments.'

b. $[\![\text{-rep}]\!] = \lambda V.\lambda e[e \in {}^*V \ \wedge \ |e| > 1 \ \wedge \ \forall e', e'' \preceq e[\theta(e') = \theta(e'')]]$
'/-rep/ takes a verb V and gives the set of plural V-ing events such that all subparts have the same thematic arguments.'

The critical difference between the two morphemes is that /-alt/ requires that the thematic arguments of its sub-events be different; /-rep/ requires that they be the same. With /-rep/, the plurality of events must thus be distributed over a different dimension, namely, time.

7.2.6 Scopable pluractionality

We will return to the compositional semantics of these morphemes in Section 7.4; however, we will foreshadow it here with one final piece of empirical data.

Currently, there is a similarity between a verb inflected with /-alt/ and a collective predicate like GATHER: both require a plurality to be introduced in some thematic role. The parallel is illustrated in (253) and (254), where the form with a singular argument is ungrammatical in both.

(253) a. * MIRKO GATHER.

b. BOYS IX-arc GATHER.
'{The boys/*Mirko} gathered'

(254) a. * ONE PERSON FORGET-alt ONE WORD.

b. MANY PEOPLE FORGET-alt MANY WORDS.
'Many people forgot many words'

However, it turns out that the behavior of /-alt/ diverges from collective predicates under distributive operators like EACH. The collective predicate GATHER is ungrammatical under *each*, indicating that EACH distributes down to atomic individuals, yielding the same bizarreness in (255a) as in (253a). On the other hand, a verb inflected with /-alt/ is fine under EACH, as in (255b).

(255) a. * EACH BOY GATHER.

b. BOY EACH-EACH FORGET-alt BRING CAMERA.
'Each boy forgot to bring a camera.'

Intuitively, the explanation for the acceptability of (255b) is that a distributive quantifier introduces a plurality of events and agents *from a global perspective*. The morpheme /-alt/ is somehow able to escape from the distributive scope of EACH to be satisfied by the global plurality.

This state of affairs turns out to be formally identical to the puzzle of dependent indefinites under distributive quantifiers (Balusu 2006, Henderson 2014). The puzzle can be illustrated using data from Kaqchikel Mayan (Henderson 2014). In Kaqchikel, reduplicating a numeral (e.g. *ju-jun*, 'one-one'; *ox-ox*, 'three-three') yields the meaning that the indefinite varies with respect to another argument in the sentence; as such, it is licensed by a plural (as in (256b)) and ungrammatical if all other arguments are singular (as in (256a)). But, just like /-alt/ in LSF, reduplicated numerals in Kaqchikel can also be licensed by quantifiers which distribute to atoms, as in (256c). (Like EACH in LSF, Kaqchikel *chikijujunal* is ungrammatical with collective predicates (Henderson 2014, f.n. 14).)

(256) Kaqchikel Mayan (data from Henderson 2014)

a. * Xe'inchäp <u>ox-ox</u> wäy.
I-handle three-three tortilla
Desired reading: 'I took (groups of) three tortillas.'

b. Xeqatij ox-ox wäy.
we-eat three-three tortilla
'We each ate three tortillas.'

c. Chikijujunal ri tijoxela' xkiq'etej ju-jun tz'i'.
each the students hugged one-one dog
'Each of the students hugged a dog.'

Following the spirit of Henderson 2014, our solution to this problem will be to allow /-alt/ (and /-rep/) to take scope outside of the distributive operator, checking plurality at different levels. Following the discussion of iconicity in §7.3, we will give a new argument in favor of this kind of analysis, based on the interaction of iconicity with the compositional semantics.

7.2.7 Summary: pluractionality

Up to this point, the pattern of pluractional verbs in French Sign Language fits perfectly into a broader typology of pluractionality in spoken languages: verbal inflection, through reduplication, indicates a plurality of events, whose distribution over various dimensions may be specified by the morpheme in question. We observed a compositional puzzle that was formally identical to the puzzle of licensing dependent indefinites in nominal domain.

The following section, however, shows that the patterns in LSF go beyond this basic typology: specifically, LSF may additionally communicate information about an event through an iconic mapping.

7.3 Iconicity

7.3.1 Iconicity in LSF verbal forms

We will claim that the rate of reduplication in LSF pluractional verb forms is iconically mapped to the rate of event repetition over time. Roughly speaking, GIVE-rep, when signed slowly, means that the giving events happened slowly; GIVE-rep, when signed quickly, means that the giving events happened quickly.

Formally, we use the following definition of iconicity:

(257) A structure is **iconic** if there is a non-arbitrary structure-preserving mapping from the form of a sign to its meaning.

Critically, if *geometric* structure (i.e. measurement) is preserved, then analog phonetic differences produce analog semantic effects. This is in contrast to the discrete, combinatorial system that is generally assumed for generative grammar, which is not able to generate patterns of gradient interpretation. Following Emmorey and Herzig 2003, we can thus use the gradient interpretation of gradient phonetic changes as a diagnostic for iconicity.

For LSF, we claim that the phonetic form of a pluractional verb includes gradient temporal information that is preserved in its interpretation. That being said, it's immediately clear that it's not *absolute* speed that is preserved—for example, GIVE-rep, signed slowly, can refer to an event which transpires of the course of several days, even though it clearly doesn't take several days to pronounce the verb.

(258) BOOK 1-GIVE-a-rep-slow.
Compatible with: 'I gave books over the course of several days.'

We will argue that what the sign preserves, then, is *relative* speed. But, if only relative speed is preserved, then in order to find gradient effects, we need to look at comparative examples, since a single speed can't be evaluated without a frame of reference.

That is what we will do, in two different ways. First, we will look at comparative paradigms, where multiple levels of speed are interpreted in comparison. Second, we will look at examples with acceleration or deceleration: change of speed within a single verb form. We will show that both of these kinds of cases are interpreted as expected from an iconic mapping, with gradience in the phonetic form interpreted as gradience in the meaning.

Example (259) presents a comparative paradigm. The verb GIVE-rep appears at three speeds: slow, fast, and medium.

(259) a. BOOK 1-GIVE-a-rep-slow.
b. BOOK 1-GIVE-a-rep-fast.
c. BOOK 1-GIVE-a-rep-medium.
'Again and again, I gave a book to him.'

Figure 7.6 provides graphs that show the speed of repetition in each of these three forms. In the graphs below, time appears along the x-axis; forward motion of the hand is indicated by a black bar; pauses and reset motions are indicated with white space.

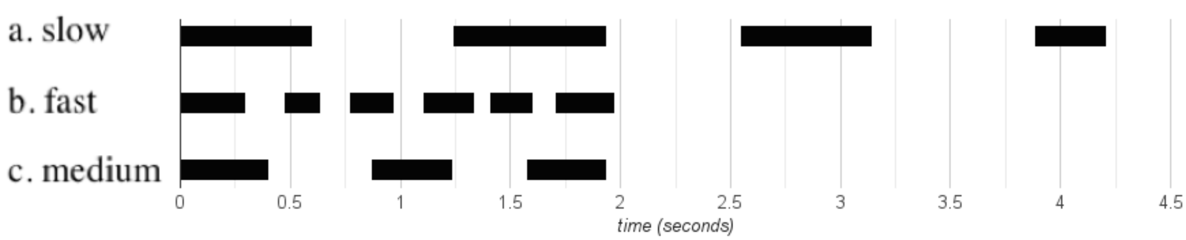


Figure 7.6: Graphs of forms at three different speeds in a comparative paradigm.

The finding is that, judged independently (with a simple interpretation question: 'What does this mean?'), there is a binary distinction among the forms. The first one, GIVE-rep-slow, is interpreted as slower than some default rate; in a neutral context, (259a) was interpreted as denoting giving events that occurred over the course of several days. (259b) and (259c) are judged to be true in the same scenarios, denoting giving events that occurred multiple times in the same day. This is exactly what we expect if only relative speed is preserved; in isolation, the forms are evaluated with respect to a default rate (here, perhaps 'once per day'), but, without comparison to another form, there is no way to get gradient judgments.

On the other hand, when the signer is asked to *compare* the meanings of forms, gradient judgments emerge between all three forms. Our signer's own description of the situation was very incisive, so we include a translation (from LSF) of this response here.

> "Of the three, for the second and the third, the situations are the same, *but* the timing is different: fast or slow—I'll explain.
>
> "The second [fast]: 'give-give-give book' means the person was like 'ask-ask-ask!' I gave-gave-gave.
>
> "The third [medium]: 'give-give-give' means the person was like 'ask please ... ask please give-me ... ask please.' I give-give.
>
> "The level of the degree is different. The idea's the same."

Thus, gradient effects appear in comparative paradigms.

Second, we can see gradient effects in a single verb if we allow change in speed: acceleration or deceleration. The following paradigms are replicated both in LSF and in ASL. The importance of this replication is to emphasize the stability of the iconic component across sign languages; we have no empirical findings so far to show that the iconic component is at all different between the two languages, and, indeed, there are theoretical reasons why we expect this to be the same among sign languages. Additionally, since much of the literature on verbal inflection has described ASL, we want to make the point that these arguments carry over to ASL as well.[3]

Example (260) provides two forms of the verb GIVE in LSF: accelerating and decelerating. As before, Figure 7.7 provides a graph of the motion, with black lines indicating the forward component of each repetition.

(260) **LSF**

a. MIRKO CHILD BOOK GAVE-rep-accelerating.

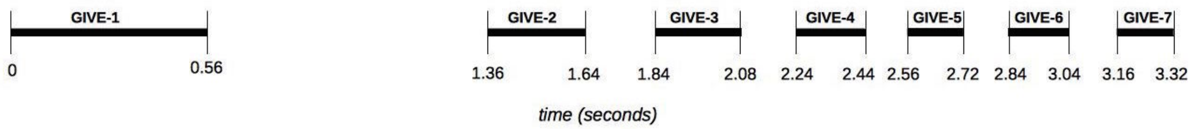
b. MIRKO CHILD BOOK GAVE-rep-deceleration.

The first of these forms is interpreted as denoting an event which accelerates in rate; the second is interpreted as denoting an event which decelerates in rate.

In fact, it's possible to preserve quite a lot of information in the iconic mapping. Figure 7.8 shows the phonetic time-course graphs for two forms of GIVE-rep in ASL, as seen in (261): the interpretation is that the giving events increase in frequency to a plateau that lasts for a short or long period of time before the rate of events decreases again.

[3] On the other hand, the grammaticalized component of pluractional morphemes does seem to show variation between the two languages. ASL is also able inflect verbs with either /-rep/ or /-alt/; however, the conditions for /-alt/ seem to be less strict: thematic participants don't need to vary, as long as the events are inferred to be different *kinds* of events.

a. Acceleration



b. Deceleration

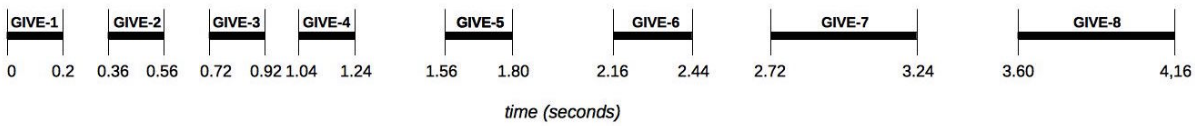


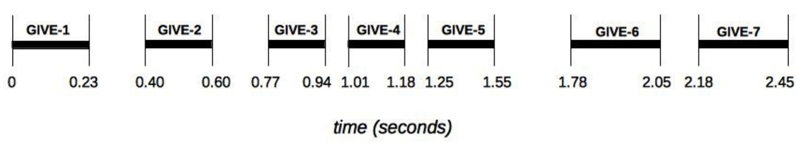
Figure 7.7: Time-course diagrams of accelerating and decelerating GIVE-rep (LSF)

(261) **ASL**

a. ME SECRETARY PAPERS GIVE-rep-slow/fast[short]/slow.

b. ME SECRETARY PAPERS GIVE-rep-slow/fast[long]/slow.
'I gave the secretary papers at a rate that sped up to a {short/long} plateau before slowing down again'

a. Short plateau



b. Long plateau

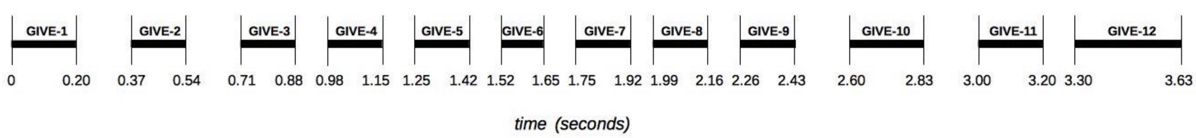


Figure 7.8: Time-course diagram of 'plateau' inflection of GIVE-alt (ASL)

In both LSF and ASL, these inferences about the rate of the event are *at-issue entailments*, that can scope low under negation, conditionals, and distributive quantifiers. Sentences (262) and (263) demonstrate this with negation; these pairs of sentences are not contradictory; the meaning is that the subject gave books at a decelerating pace.

(262) **LSF**
MIRKO BOOK GIVE-rep-speeding-up NOT. IX BOOK give-rep-slowing-down DOWN.
'Mirko didn't give books at an accelerating rate. He gave books at a decelerating rate.'

(263) **ASL**

‘JOHN NOT PAPERS GIVE-alt-speeding-up. IX PAPERS GIVE-alt-slowing-down.’

Sentences (264) and (265) show the behavior under *if*; here, signers infer that the secretary will only be happy if the subject gives papers at an accelerating rate.

(264) **LSF**

IF MIRKO PAPERS GIVE-rep-speeding-up, IX SECRETARY HAPPY.
‘If Mirko gives papers at an accelerating rate, the secretary will be happy.’

(265) **ASL**

IF JOHN PAPERS GIVE-alt-speeding-up, SECRETARY WILL HAPPY.
‘If John gives papers at an accelerating rate, the secretary will be happy.’

Finally, we observe that iconic meanings can scope below distributive operators. In particular, note that a large number of slowly repeating events, when summed together, can yield a sequence of events that occur at a fast rate, as illustrated in Figure 7.9.

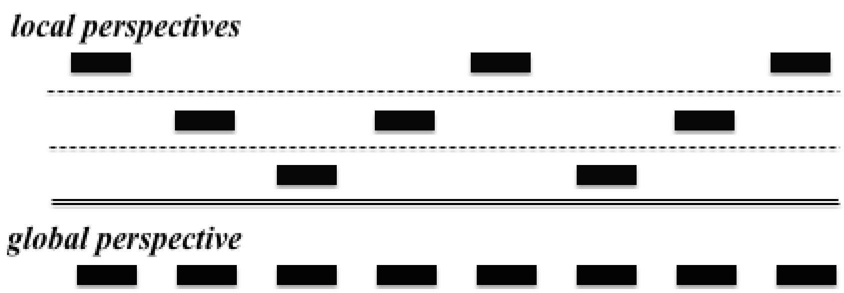


Figure 7.9: Local vs. global perspective of a plural event

In the English sentence ‘Each worker gave the secretary papers slowly,’ the adverb *slowly* takes scope below the distributive operator *each*; the result is that the sentence is compatible with a situation in which there are so many workers that the (solitary) secretary ended up receiving papers at a very fast rate. In LSF and ASL, we see the analogous result that the iconically-encoded information about the rate of the event may scope below a distributive operator; thus, the ASL discourse in (266) is judged as non-contradictory, parallel to the English gloss.

(266) **ASL**

EACH WORKER SECRETARY PAPER GIVE-rep-slow. BUT, MANY WORKER NUMEROUS, ONE SECRETARY. SO SECRETARY RECEIVE-alt-fast FAST.
‘Each worker gave the secretary papers *at a slow rate*. But there are many workers and one secretary. So the secretary received papers *at a fast rate*.’

The discourse in (267) provides a more complex example that makes the same point. Here, from the point of view any given worker, the giving events accelerate; however, the total number of workers is not constant since workers leave throughout the day, so from the point of view of the secretary, the giving events decelerate. The ASL discourse in (267) is judged as non-contradictory.

(267) **ASL**
ALL WORKER ARRIVE 9. EACH GOAL FINISH 10 FORM THEN LEAVE HOME. SOME FINISH FAST 10AM, SOME ALL-DAY. BEGIN DIFFICULT, GET-USED SPEED-UP. **EACH WORKER SECRETARY PAPER GIVE-rep-speeding-up**. BUT, WORKER FINISH, LEAVE. SECRETARY PAPER RECEIVE-alt-slowing-down.
'All the workers arrive at nine. Each has to finish ten forms, then heads home. Some finish quickly and are done at 10am; others take all day. At first it's difficult, but they get used to it and get faster. **Each worker gives papers to the secretary at an accelerating rate**. But, when the workers finish, they leave. The secretary receives papers at a decelerating rate.'

Altogether, these examples show that the iconic meaning introduced by the predicate is an at-issue entailment, which may scope below other operators in the sentence.

7.3.2 The iconic mapping

With all the structure that is preserved, what is notably *not* preserved is the exact number of repetitions. For example, in (260b), there is no inference that there the speaker gave something exactly eight times, even though, if you count the black bars in Figure 7.7b, this was the number of times the signer's hands moved.

In fact, this is no surprise; there is a general finding in the sign language literature that "three means plural (and sometimes two is enough)," which goes hand-in-hand with the more general cognitive finding (Carey 2009) that relative cardinality judgments are much easier than absolute cardinality judgments. Yet, there is a challenge in the formalization; on one hand, a huge amount of information is preserved by the iconic mapping, but it critically doesn't maintain a one-to-one correspondence with the exact repetitions. Thus, we need a mechanism to innocently 'add points' to a sequence without altering important global properties of the sequence (like acceleration, etc.).

Our answer to this puzzle is to associate an iconic sequence not with a discrete set of points, but with a continuous of distribution of events over time. Roughly speaking, then, the accelerating sequence in Figure 7.10a would be associated with the positively-sloped red line that appears above it. We can now formalize what it means to be insensitive to 'absolute rate' and 'absolute number:' the iconic mapping can innocently stretch a coutour by multiplying by a constant along the x-axis or y-axis. Stretching or compressing along the x-axis allows us to ignore absolute speed, as in Figure 7.10b; stretching along the y-axis allows us to add more points to the sequence, as in Figure 7.10c.

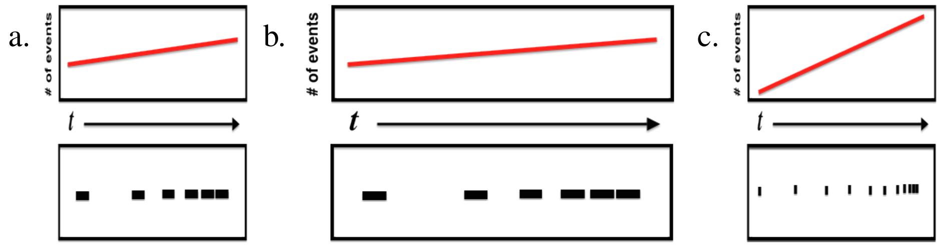


Figure 7.10: Stretching along the axes yields timing and number insensitivity

Technically, there are a number of different options for how to map a set of discrete points to a continuous contour. A standard strategy in statistics is to use a kernel density estimation (see Silverman 1986 for an overview). Essentially, this is a way of estimating the rate of events at a given point in the sequence by counting the number of events within a fixed-size window centered around that point. The graph created by allowing the window to move along the x-axis (time) will be the contour associated with the sequence of points. Figure 7.11 demonstrates this idea using a bell-curve-shaped window: the estimated rate at $t = 25$ is the sum of the values of the red lines.

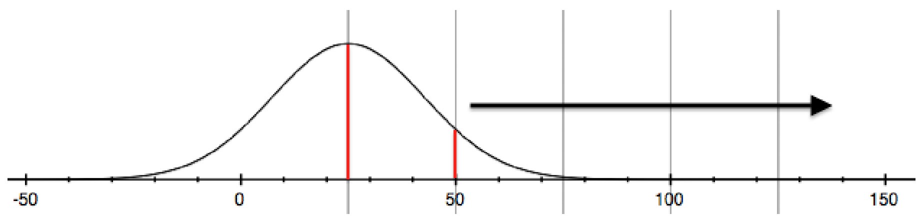


Figure 7.11: Illustration of a kernel density estimation calculation

An example is given in Figure 7.12. Here, a decelerating sequence of events is mapped to the contour that is layered on top of it. Formally, the resulting representation is very similar to a histogram, but the smoothed technique here escapes from several pathologies that arises from the chunking properties of histograms.

The exact details of the account are at this point largely arbitrary (although they could in principle be tested), so they shouldn't, in themselves, be taken too seriously. Nevertheless, what we have hoped to show is that it is possible to define a mapping that is finely sensitive to event contour but not absolute number, without appealing to cognitive primitives like [+acceleration] that hardwire certain features of the event representation.

Generally speaking, though, the iconic mapping will associate a sequence of phonetic movements with a continuous contour (like the curve in Figure 7.12) that represents the rate of events—the number of events over time. This contour is subject to optional transformations, as in Figure 7.10. We say the verb is true of any sequence of events which matches the resulting set of contours.

In Figure 7.13, the phonetic form appears in semantic interpretation brackets; the meaning is

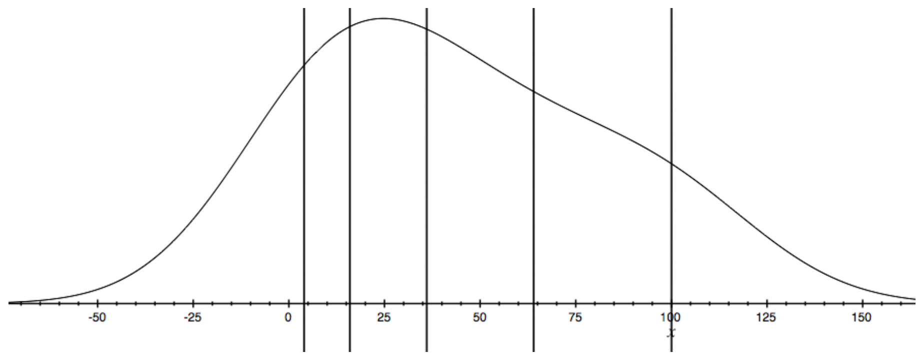


Figure 7.12: Output of a kernel density estimation. The downward slope of the line indicates that event occurrences become less frequent over time.

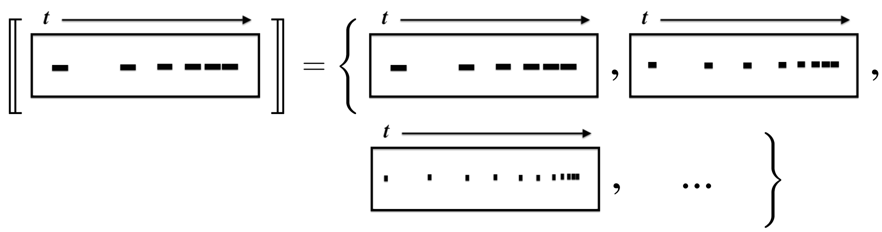


Figure 7.13: Semantic interpretation of a phonetic form

the set of event sequences on the right, all of which match the same contour (modulo stretching). But now, notice that what we've done is simply to associate a verb with a set of plural events: in other words, we have defined a predicate of type $\langle v, t \rangle$—a set of events that we can pop into a formal definition.

That's what we do in (268); the definition in (268) is exactly the same as the one that appears earlier in (252), but here, we replace the generic plurality condition '$|e| > 1$' with an iconic predicate, a function that takes a phonological form and a verb, and returns a set of event sequences. For a phonetic form Φ, call this mapping $\textbf{Icon}^{\Phi}$. In (268), $\textbf{Icon}^{\Phi}$ yields plurality, since multiple motions map to a plural event. The remainder of the definition remains the same, since the new predicate is a formal object of exactly the same type as the old one.

(268) a. $[\![\text{-alt}]\!] = \lambda V.\lambda e[{}^{*}V(e) \wedge e \in \textbf{Icon}^{\Phi} \wedge \exists e', e'' \preceq e[\theta(e') \neq \theta(e'')]]$
b. $[\![\text{-rep}]\!] = \lambda V.\lambda e[{}^{*}V(e) \wedge e \in \textbf{Icon}^{\Phi} \wedge \forall e', e'' \preceq e[\theta(e') = \theta(e'')]]$

This theoretical move follows Schlenker, Lamberton, and Santoro 2013, who observe that there is no fundamental opposition between iconic properties and formal properties; there's no problem in allowing an iconically defined predicate to be incorporated directly into a formal system. (Schlenker et al. develop such a system to account for iconic properties of pronominal forms in ASL and LSF.)

On the other hand, this theoretical move has a non-trivial effect on the system's expressive power. Specifically, when we strip away iconic predicates from the definition in (268), we are left with exactly the discrete system that is assumed for spoken language; the system is thus at least as expressive as spoken language. But, we've also seen that iconic predicates can express meaning in ways that a purely combinatorial grammar cannot; the specific case that we looked at was gradient interpretation. So, in fact, the system that we are left with is strictly *more* expressive than 'spoken language.' We can thus view a combinatorial grammar with iconicity as a fine-graining of a purely combinatorial grammar.

7.4 Compositional semantics

Until now, we have given what are essentially sentence-level truth conditions; in this section, we turn to the compositional semantics. One empirical fact will require particular consideration: as we saw in §7.2.6, the pluractional morpheme /-alt/ can be licensed by distributive operators that elsewhere prohibit collective readings. The relevant data is repeated in (269) and (270).

(269) BOY EACH-EACH FORGET-alt BRING CAMERA.
'Each boy forgot to bring a camera.'

(270) * EACH BOY GATHER.

The condition of thematic variation in our characterization of /-alt/ requires at least two individuals to be involved in a given event, but (269) shows that EACH distributes to atomic individuals. As we saw in §7.2.6, this puzzle is formally equivalent to the licensing of dependent indefinites under distributive operators. In order for the variation condition to be satisfied, it must somehow scope above the distributive scope of EACH.

We will propose an analysis in which a pluractional verb is a **scope-taking predicate**. Following Henderson 2014, we will propose that the meaning of a pluractional is a predicate that checks for a plurality of events. However, departing from Henderson, we will argue that this predicate can take scope at different levels with a non-trivial semantic effect; in particular, allowing a pluractional verb to scope above a distributive operator is exactly the mechanism by which we will be able to check for the existence of an 'evaluation plurality' capturing the observation above.

Novel evidence for this kind of solution comes from an interaction with iconicity: a slow movement of /-alt/ under EACH must denote an event which happens slowly from a global perspective, demonstrating that the iconic predicate (as part of the pluractional verb) is taking scope above the distributive operator.

7.4.1 Definitions and examples

This section presents explicit definitions and derivations.

Following Krifka 1992 and Kratzer 2008, among others, predicates are inherently pluralized. For example, *arrive* denotes the algebraic closure of arriving events.

(271) $^{*}P = \{x | \exists P' \subseteq P[x = \bigoplus P']\}$ where $\bigoplus P$ only defined for $P \neq \emptyset$
'$^{*}P$ is the set containing all individuals that you can make by summing non-empty subsets of P'

A definite plural denotes a sum individual.

(272) $[\![\text{THE BOYS}]\!] = \bigoplus \text{boy}'$

Arguments of a predicate are introduced by thematic role operators, as in (273). Following Krifka 1986 among others, we assume cumulativity of thematic roles; that is, for all events e, e', agent$(e \oplus e')$ = agent$(e) \oplus$ agent(e').

(273) **ag** :: $\langle vt, \langle e, vt\rangle\rangle$
$[\![\textbf{ag}]\!] = \lambda V x e[V(e) \wedge \text{agent}(e) = x]$

Pluractional morphemes are predicates of events that include (at least) the condition that there are more than one events. (For the present, we will ignore iconicity.)

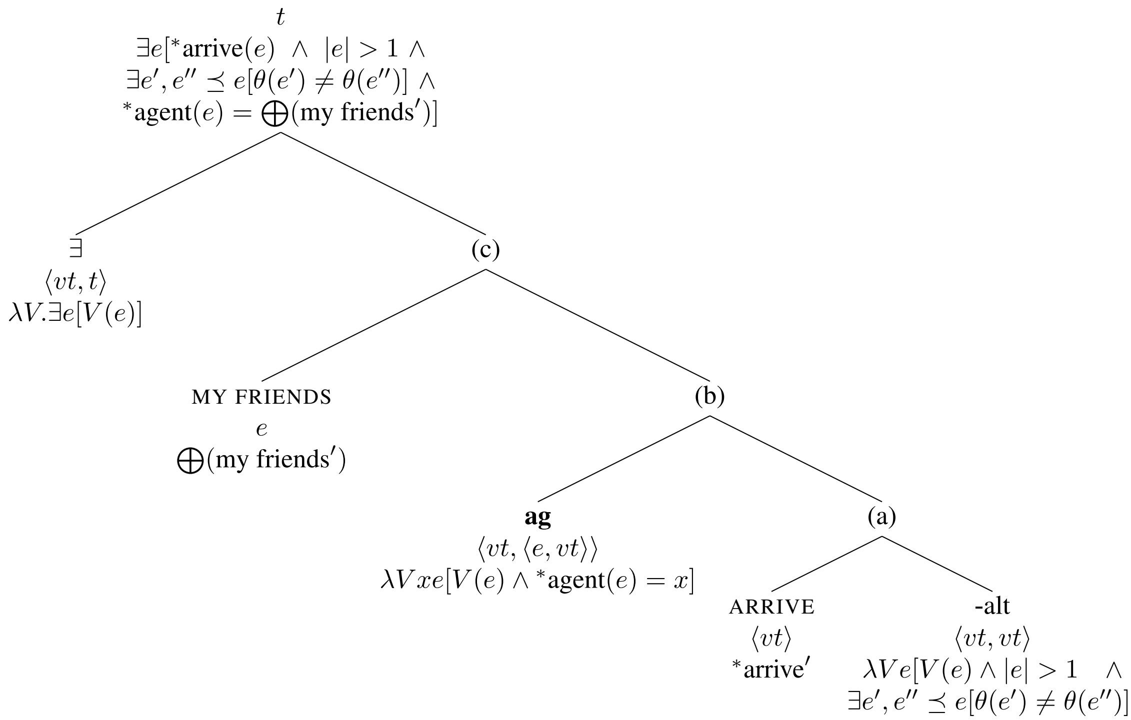
(274) /-alt/ :: $\langle vt, vt\rangle$
$[\![\text{-alt}]\!] = \lambda V e[V(e) \wedge |e| > 1 \wedge \exists e', e'' \preceq e[\theta(e') \neq \theta(e'')]]$

(275) /-rep/ :: $\langle vt, vt\rangle$
$[\![\text{-rep}]\!] = \lambda V e[V(e) \wedge |e| > 1 \wedge \forall e', e'' \preceq e[\theta(e') = \theta(e'')]]$

The tree in (277) provides an example derivation for sentence (276). The verb ARRIVE is number-neutral, including both singular and plural events; at node (a), it combines with /-alt/, which restricts this denotation to plural events, and further imposes the condition of thematic variation over these events. At node (b), an agent argument position has been introduced, and at node (c), this has been filled by the sum of my friends. Because 'MY FRIENDS' is plural, it provides a thematic argument that can satisfy the condition of thematic variation imposed by /-alt/. Finally, the event argument is existentially closed.

(276) MY FRIENDS ARRIVE-alt.

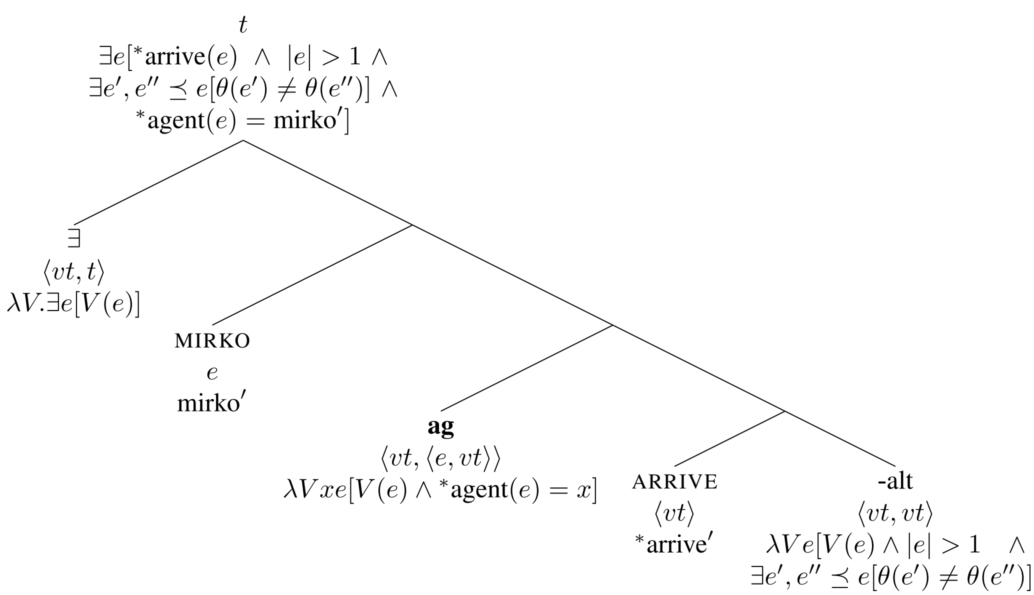
(277)



The sentence in (278) is ungrammatical; the tree in (279) show where this goes wrong. The derivation proceeds as before; the difference here is that the subject of the sentence is a singular individual, thereby guaranteeing that the sentence be a contradiction. Specifically, /-alt/ imposes the condition of thematic variation. Since **ag** is the only node introducing a thematic role, this amounts to the constraint that $\exists e', e'' \preceq e[\text{agent}(e') \neq \text{agent}(e'')]$, which entails that $|\text{agent}(e)| \geq 2$. This contradicts the condition that $\text{agent}(e) = \text{mirko}'$.

(278) * MIRKO ARRIVE-alt.

(279)



We now turn to examples with distributive operators, which, as we have observed, are grammatical with /-alt/. The integration of quantification with event semantics is not entirely trivial; for recent discussion, see Champollion 2014. Since the issues of integration are not immediately relevant for the discussion here, however, we will simply hardwire a definition for 'BOY EACH-EACH'. In the definition below, note that the condition 'boy′(x)' is not algebraically closed (i.e. it is not preceded by a *-operator); thus, the condition 'boy′(x)' entails that x is atomic. For a similar analysis of determiner *each* (in English and other languages), see Champollion 2015b.

(280) $[\![\text{BOY EACH-EACH}]\!] = \lambda P_{\langle e,vt\rangle}\lambda e[\forall x[\text{boy}'(x) \rightarrow \exists e'[e' \preceq e \wedge P(x)(e')]] \wedge \forall e' \preceq e[\exists x[\text{boy}'(x) \wedge P(x)(e')]]]$

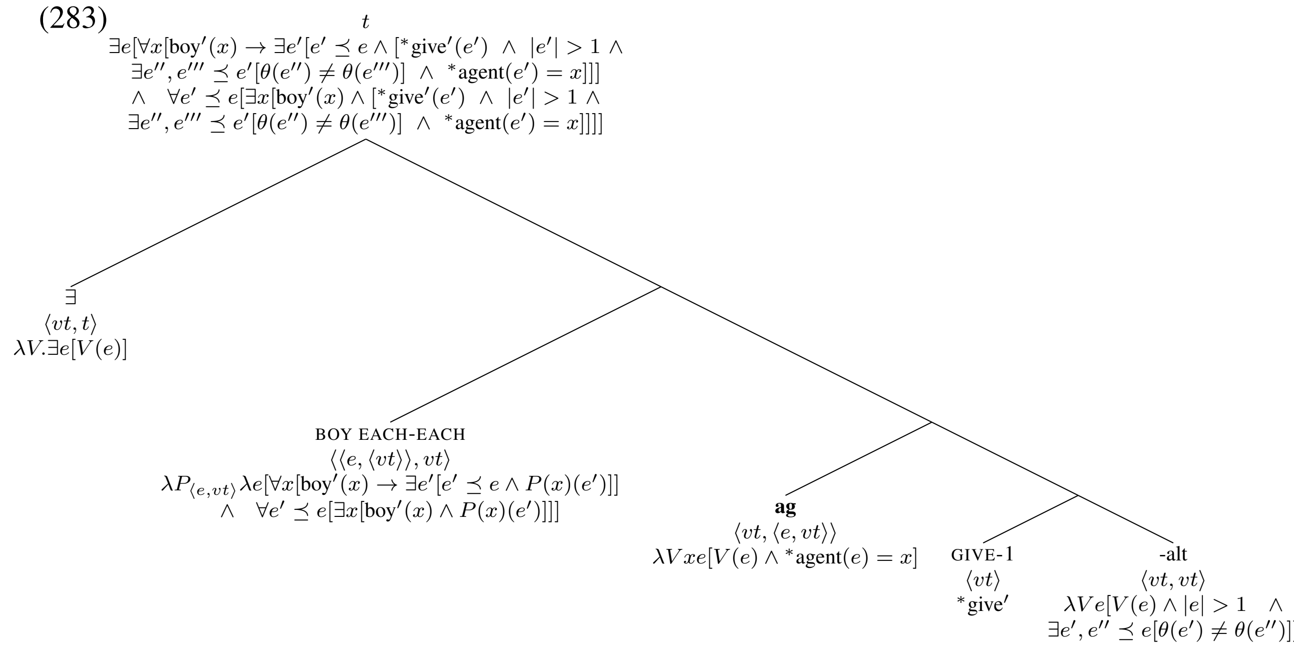
'Given a predicate P, return the set of events e such that, for each atomic boy x, there is an $e' \preceq e$ such that $P(x)(e')$, and, conversely, for every $e' \preceq e$, there is an atomic boy x such that $P(x)(e')$.

But here, the previous method of composition produces a contradiction, producing the meaning in (282). In both conjuncts, note that the agent of e' is an atomic boy. As in (278), this means that it is impossible to satisfy the requirement that there be $e'', e''' \preceq e'$ with different agents. Thus, the meaning in (282), derived through the tree in (283), incorrectly predicts sentence (281) to be ungrammatical.

(281) EACH-EACH GIVE-1-alt.

(282) $\exists e[\forall x[\text{boy}'(x) \rightarrow \exists e'[e' \preceq e \wedge [^*\text{give}'(e') \ \wedge \ |e'| > 1 \ \wedge \ \exists e'', e''' \preceq e'[\theta(e'') \neq \theta(e''')] \ \wedge \ ^*\text{agent}(e') = x]]] \wedge \ \forall e' \preceq e[\exists x[\text{boy}'(x) \wedge [^*\text{give}'(e') \ \wedge \ |e'| > 1 \ \wedge \ \exists e'', e''' \preceq e'[\theta(e'') \neq \theta(e''')] \ \wedge \ ^*\text{agent}(e') = x]]]]$

(283)

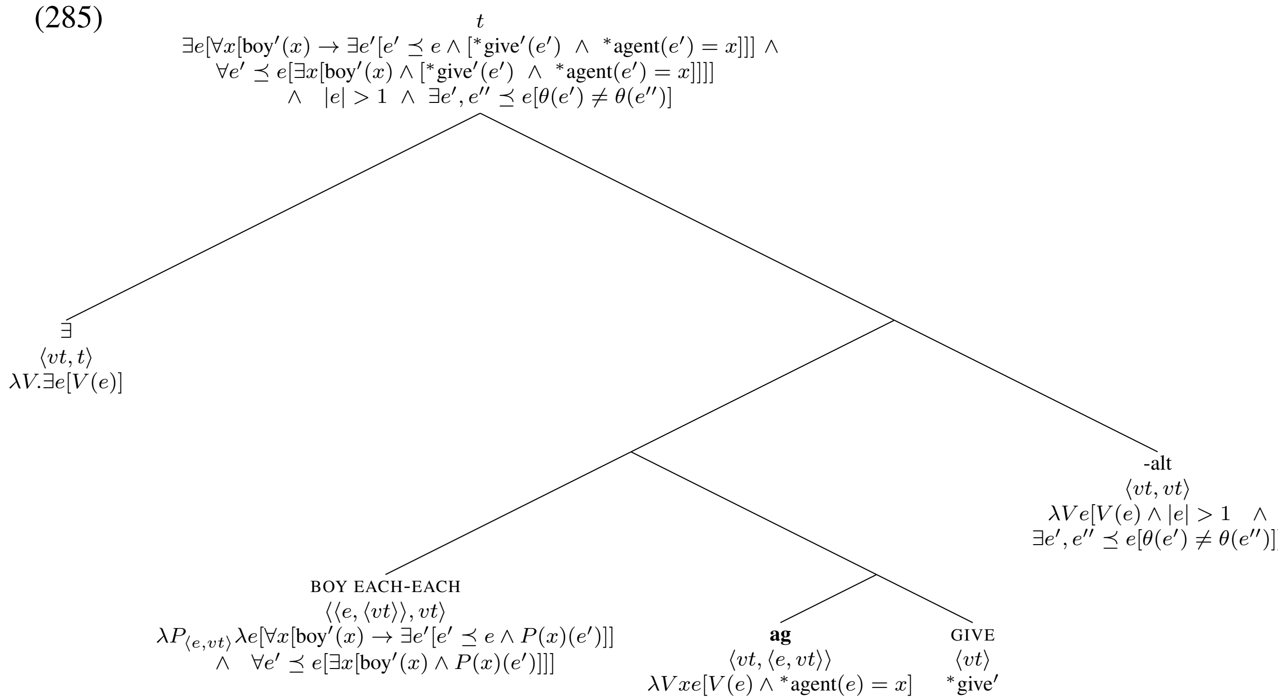


The solution is to allow the predicate /-alt/ to be evaluated in a higher position, to allow it to 'see' outside the scope of the distributive operator. As discussed in Chapter 4 for dependent indefinites, there are a number of ways in which this could be implemented, including standard mechanisms of scope-taking (QR and associates) and dynamic analyses employing 'postsuppositions' (see Henderson 2014 for discussion). In §4.4.4, it was observed that the effect of a postsupposition can be emulated by evaluating a conjunct as though it attaches to a given tree at a higher node. Thus, for relative simplicity, here we will approximate the process of scope-taking as an attachment ambiguity.

The tree in (285) is thus an alternate derivation of (281), producing the meaning in (284). Here, although the subevents e' still have atomic agents, the condition of thematic variation now applies to the global event e. The variation introduced under 'BOY EACH-EACH' can thus also satisfy the entailments of /-alt/, and there is no contradiction.

(284) $$\exists e[\forall x[\text{boy}'(x) \rightarrow \exists e'[e' \preceq e \wedge [{}^*\text{give}'(e') \;\wedge\; {}^*\text{agent}(e') = x]]] \wedge \forall e' \preceq e[\exists x[\text{boy}'(x) \wedge [{}^*\text{give}'(e') \;\wedge\; {}^*\text{agent}(e') = x]]]] \wedge \;\; |e| > 1 \;\wedge\; \exists e', e'' \preceq e[\theta(e') \neq \theta(e'')]$$

(285)



7.4.2 Scopable iconicity

So far, our compositional system has ignored the iconic component of /-alt/ and /-rep/ discussed in §7.3. As before, adding this in is a totally seamless process; we simply replace '$|e| > 1$' with **Icon**$^{\Phi}$ in our definitions. It turns out, though, that the attachment ambiguity proposed above makes specific predictions about the semantic contribution of the iconic predicate to the global truth conditions.

In particular, we observed in at the end of §7.3.1 that when an iconic predicate is interpreted below a distributive operator, the time-course of the global event may differ in significant ways from the time-course of the local events. (For example, a set of sequences that have a slow rate may sum to a single event sequence that has a fast rate.) Because the iconic predicate is incorporated into the meaning of /-rep/ and /-alt/, we thus expect the iconic component to be interpreted differently depending on where /-rep/ and /-alt/ attach to the tree. Specifically, when /-alt/ is forced to scope above a distributive operator in order to license the variation condition, we predict that the iconic component must also be interpreted above the distributive operator.

This prediction appears to be borne out. For example, in the ASL sentences in (286), the speed of repetition in the phonological form must match the speed of the event from a global perspective. Specifically, the sentence in (286b) *cannot* be used to describe a scenario with a slow local perspective and a fast global perspective (c.f. the interpretation of /-rep/ in (266)). In contrast, the sentence in (286b) *is* compatible with such a scenario (although it's pragmatically dispreferred, not being a particularly clear way to communicate this meaning).

(286) **ASL**

a. EACH-EACH-a BOY BOOK a-GAVE-1-alt-slow.
   'Each boy gave me books, which happened slowly from a global perspective.'

b. EACH-EACH-a BOY BOOK a-GAVE-1-alt-fast.
   'Each boy gave me books, which happened quickly from a global perspective.'

In LSF, the situation is slightly less clear, perhaps due to pragmatic factors ruling out complicated meanings. In (287a), the giving events are interpreted as happening at a slow rate from both a local and global perspective; in (287b), the giving events are interpreted as happening at a fast rate from both a local and global perspective. (Neither are reported to be compatible with a scenario with a mismatch between the local and global speeds.)

(287) **LSF**

a. BOY EACH-EACH-A BOOK A-GAVE-1-alt-slow DOWN.

b. BOY EACH-EACH-A BOOK A-GAVE-1-alt-fast MORE.

Although there are complications with the LSF example, what holds between both languages is that when /-alt/ is licensed by a distributive operator, the iconic component must be interpreted as holding (at least) at a level above that distributive operator.

7.5 Summary

Here, we focused on two reduplicative verbal forms in LSF. First, we tried to position the semantics of these forms within a broader linguistic context; we saw that the meanings fit into with more general typology of cross-linguistic pluractionality. The specific finding was that one-handed repetition (/-rep/) means distribution over time; two-handed alternating repetition (/-alt/) means distribution over participants.

We then argued that sign language forms go beyond what we've seen to date in spoken language forms. Critically, an iconic component is incorporated into both pluractional morphemes. We saw that in comparative constructions, gradient interpretation arises. Putting this together with the logical meanings, we ended up with a system that was expressively more powerful than a grammar without iconic predicates.

Finally, we discussed the compositional semantics, focusing on a puzzle about the licensing of /-alt/ under distributive operators, familiar from the literature on dependent indefinites. We provided a solution to this puzzle in terms of scope. This analysis extended seamlessly and correctly to the iconically-enriched semantics, providing a new piece of evidence for this kind of approach with the existence of 'scopable iconicity.'

Chapter 8

General Conclusions

In this dissertation, I addressed a wide range of semantic phenomena from the point of view of sign language. These topics included anaphora (Chapter 2), plurality and dependency (Chapters 3, 4, and 7), telicity (Chapter 6), and iconicity (Chapters 2, 6, and 7). Here, I will synthesize results from across the chapters to provide a bigger picture, as well as indicating some directions that have been opened for future research.

8.1 Plurality and dependency

A variety of constructions in natural language express dependency, where the value of one expression varies with the value of another—in this work, we have seen the examples of dependent indefinites, adjectives *same* and *different*, and pluractional verbs. These forms are characterized by a long-distance relationship between the dependent form and a plural or distributive licensor.

These kinds of empirical phenomena have motivated recent enrichments to semantic theory; of note, the framework of Dynamic Plural Logic is an enrichment of dynamic semantics that allows reference to functional discourse referents that are constructed 'on the fly' by the association of two pluralities (van den Berg 1996, Nouwen 2003, Brasoveanu 2012, Henderson 2014). In this dissertation, I have argued that the empirical patterns in ASL give new evidence for these enriched theories, transparently representing dependency through the use of space.

In Chapter 3, I made a novel generalization about the representation of nominal dependency in American Sign Language. I observed that numerals and the adjectives SAME and DIFFERENT may be inflected with arc-movement over an area of space associated with a plural licensor; the resulting semantic effect is to establish a dependency relation between the two semantic terms.

I argued that the environments where arc-movement is licensed are characterized by the introduction of a functional discourse referent; spatial association specifies the input of the function. Evidence for an analysis in terms of functions came from licensing conditions: arc-movement on ONE and SAME is licensed exactly where a pronoun in English can retrieve a functional antecedent. In particular, licensing is not possible under NONE (see §3.4.4 and §3.5.3).

Modulo the use of space, the sign language data exactly replicates patterns of dependency familiar from spoken language. With spatial agreement, however, dependency is made overt; we saw that sign language is able to disambiguate readings where spoken language cannot. In particular, dependent indefinites in spoken language (e.g. Hungarian and Albanian) are ambiguous when there are multiple potential licensors; in ASL, they are not (see §3.4.5 and §3.5.4).

In Chapter 7, we discussed the alternating verbal inflection /-alt/ in French Sign Language, which presented an example of dependency in the verbal domain: /-alt/ entails that a plurality of events vary with respect to some plural or distributive licensor. As with dependent indefinites in ASL, the pattern of pluractionality in LSF fits into a larger typology of known from spoken language. But, again, we showed that the sign language pattern displayed a modality-specific property—namely, the productive availability of iconic manipulations.

We proposed that the iconic component was incorporated as part of the definition of /-alt/ (and /-rep/). This made the prediction that the iconic component should be interpreted at the level at which the pluractional morpheme is evaluated. This prediction was borne out, yielding a case of 'scopable iconicity.'

In both cases, I argued that unique properties of these patterns in sign language gave insight into debates about dependency in spoken language. These debates involve the following questions.

1. What is the semantic contribution of a dependent form?
2. What is the relation between a dependent form and its licensor?
3. What is the mechanism that allows dependent forms to be licensed by operators that distribute down to atomic individuals?

New evidence from sign language involved both the use of space and iconicity. First, I took the morphological unification of dependent indefinites with SAME and DIFFERENT (through arc-movement) as evidence that their semantic analysis should be parallel; this led me to an analysis in which dependent indefinites, like SAME and DIFFERENT, are quantificational. Second, I argued that the overt spatial agreement of a dependent form with its licensor showed that the semantic analysis must be able to represent this link directly; this led me to an analysis in which dependent indefinites and SAME bear an overt anaphoric connection to their licensor. Finally, I observed that when /-alt/ is licensed by EACH, the iconic component is mandatorily evaluated above the quantifier; this supported an analysis in which dependent forms are licensed by distributive operators by taking scope above them.

8.1.1 Dynamic semantics vs. situation/event semantics

As discussed in Chapter 2, Dekker 2004 shows that, under certain assumptions, assignment functions and situations/events are equivalently fine-grained. Both represent a context that exactly verifies the truth of a sentence; the set of individuals that serve as values in the assignment function comprise the set of participants of a corresponding minimal situation/event. As a result, dynamic semantics (which employs assignment functions) and event or situation semantics (which employ events or situations) can often be used interchangeably to capture the same kinds of phenomena. This near-equivalence formed the foundation of the debate between dynamic theories and E-type theories reviewed in Chapter 2.

With the turn to plurality in this dissertation, we have seen this correspondence in yet another concrete form. Namely, both Chapter 4 and Chapter 7 analyzed dependency constructions, where the value of one semantic object varies with respect to the value of another. Yet, in Chapter 4, I analyzed the pattern of dependent indefinites using Dynamic Plural Logic; in Chapter 7, we analyzed the pattern of pluractionality using event semantics.

In either case, the analysis was chosen in order to present the empirical domain with the simplest and most intuitive analysis for the phenomenon in question, so as to highlight its essential features and properties. In the case of dependent indefinites, dependency relations are overtly realized with spatial agreement; I therefore framed my analysis within the tradition of dynamic semantics, where anaphoric relations can be cleanly stated. In the case of pluractionality, the dependent variable is of an event type; event semantics therefore presented itself as the most perspicuous framework for analysis.

Looking forward, the clear next step is to build a system that unifies the two domains, an undertaking that promises to be productive on several different fronts. Theoretically, both dynamic semantics and event semantics have undergone recent enrichments to account for complex data involving plurality; assessing the degree to which each framework can capture the insights of the other provides an exciting new incarnation of the debate between dynamic semantics and E-type theories. A unified theory would also allow extension to cases where nominal plurality and verbal plurality interact, a domain explored at great depth in spoken language, notably by Boolos 1984, Higginbotham and Schein 1989, Schein 1993, Landman 2000, and Kratzer 2000.

In sign language, the interaction of nominal and verbal plurality is of particular empirical relevance for cases where a pluractional verb shows spatial agreement with a plural noun (see, e.g., Fischer 1973, Klima and Bellugi 1979, Wilbur 2009). I leave the analysis of verbal agreement under the present framework as an open project for future research.

8.2 Iconicity

A recurring theme in this dissertation—particularly in Part II—has been the description of iconic phenomena and their interaction with other grammatical patterns in sign language.

I focused primarily on iconicity in the verbal domain, where cases of iconicity are relatively more abstract and less documented than cases of iconicity in the nominal domain. For both singular and pluractional forms, I argued that the motion of the phonetic form of a verb is systematically interpreted to reflect the progression of the events in its denotation.

One of the interesting descriptive generalizations that emerged was the observation that although some components of the phonetic form may be interpreted, others may not be. We saw this fact instantiated at several different points. For both singular and pluractional forms, we saw that relative measure is preserved, but absolute measure is not. In the case of singular verbs, we saw that abrupt deceleration in the phonetic form is interpreted not as abrupt deceleration in the meaning, but as a way of marking distinguished points in the event progression. Finally, in the case of pluractional verbs, we observed that rate-related information is iconically interpreted, but that exact number of repetitions is not.

These patterns can be understood under Schlenker, Lamberton and Santoro 2013's conception of iconicity as a structure preserving mapping: a given mapping may preserve some kinds of structure (e.g. merological, topological, geometric, etc.), but not others. For the patterns presented here, I have described mappings that preserve the relevant level of iconic information. This dissertation has only scratched the surface of the question, however; a complete understanding of iconic interpretation must address pictorial representation more generally, as in Greenberg 2013, as well as the cognitive principles that underlie the perceptual system, as in Carey 2009.

Throughout my discussion of iconic phenomena, one of my goals has been to emphasize those places where iconicity interacts in non-trivial ways with the combinatorial grammar. I have argued that in order to descriptively capture the data, the interpretive system must be able to concurrently manipulate logical and iconic forms. Here, I review the diverse collection of these 'points of interface' that we have seen, in which iconic meanings in some way feed the combinatorial grammar.

1. The representation of an endpoint of a gradient iconic scale induces a categorical grammatical distinction in telicity (Chapter 6).

2. Intermediate points on an iconic scale may be targeted by the restitutive reading of again-ambiguities (§6.6.1).

3. In the case of /-alt/ in LSF, an iconically-generated plurality (via reduplication) induces formal licensing patterns (§7.2.3).

4. Iconic manipulations may be interpreted as at-issue entailments, interpreted below other operators in the sentence (§7.3.1).

5. Iconically-generated pluralities may take scope with respect to other operators; iconic manipulations are interpreted at the resulting level (§7.4.2).

I take this litany of examples as strong evidence that meaning must be computed by an interpretive system that incorporates both iconic and logical meanings.

The conception of iconic meaning as something that can be formally described and that can formally interact with the combinatorial grammar allows a variety of new questions to be asked. First, defining iconicity as a structure-preserving mapping, we are better able to characterize its formal properties, and thus separate linguistic meaning into iconic and non-iconic dimensions (an endeavor dating back to Bellugi and Klima 1976). For example, building on work by Emmorey and Herzig 2003, we saw that the gradient interpretation of gradient phonetic changes is a property characteristic of iconic mappings that preserve geometric structure.

Having defined these two dimensions of meaning, we can then ask questions that are familiar to formal semanticists. Is the iconic dimension characterized by certain projective properties? Are there linguistic forms in the non-iconic dimension that are sensitive to meanings in the iconic dimension? These are exactly the sort of questions that have been asked about other kinds of multidimensional meanings, such as focus, conventional implicature, and contextual information.

Iconic forms are grounded in more domain-general cognitive systems; this is evidenced in part by the ability of non-signers to be able to make inferences about iconic meanings in sign language (examples reviewed here include Emmorey and Herzig 2003 on pronominal forms and Strickland et al. 2015 on verbal telicity). Iconcity thus has bearing on questions about modularity of language: the interpretation of iconic forms in language moves us away from a view in which language is completely encapsulated in a linguistic module. It is only by building a system that incorporates both iconic and logical meanings that we will be able to eventually address these broader cognitive questions.

8.2.1 Iconicity beyond sign language

Thanks to its visuospatial modality, sign language shows a particularly high degree of iconicity, permeated throughout the linguistic system. As such, sign languages provide the obvious place to begin investigating the behavior of iconic phenomena.

Nevertheless, spoken language, too, displays iconicity in at least two ways. First, spoken language may communicate iconic meaning through modifications of the auditory speech signal. Second, spoken language may be accompanied by iconic co-speech gestures. Here, I will briefly sketch some possible directions for investigation in spoken language iconicity and co-speech gesture.

Although the auditory channel is less suited to iconic representations than the visual modality, there nevertheless exist a number of iconically-grounded constructions. Of particular note to the patterns discussed in this work, spoken language frequently employs reduplication to express notions of plurality; as we saw in Chapters 3, 4, and 7, reduplication can be used in spoken language to form both dependent indefinites and pluractional verbs. From an iconic perspective, this is unsurprising: a plurality of syllable repetitions is associated with a semantic plurality. (This connection is discussed as early as Sapir 1921, who observes the 'self-evident symbolism' of reduplication.) In these cases, the historical connection is clear; I leave it as an open question whether any of these forms can be productively modified in iconic ways.

In fact, cases of repetition in English give insight into the path to grammaticalization. Even in English, repetition is used productively to indicate verbal plurality, when a verb is conjoined to itself arbitrarily many times (as in (288a)), or when the adverb *again* is conjoined to itself arbitrarily many times (as in (288b)).

(288) a. The bell rang and rang (and rang).
b. The bell rang again and again (and again).

Of note, these forms do not entail that there are exactly two (or exactly three) repetitions of the event, as we would expect if each verb carries a single event variable that is evaluated with a shifted reference time (as in Partee 1984). Rather, just as in the sign language examples, there is an inference of event plurality, but not of exact number; this fact is exemplified in the contrast in (289).[1] Nevertheless, as in sign language, some information about quantity is preserved: more repetitions of the event are inferred from more repetitions of the verb.

(289) a. The bell rang twice. I heard it both times.
b. # The bell rang and rang. I heard it both times.

Further iconic properties of these constructions remain to be investigated.

A case of iconicity that in some sense is even closer to the sign language examples is the case of gesture accompanying spoken language. A large body of work has investigated the interaction of gesture with spoken language (see Kendon 2008 for an overview) as well as the relation between gesture and iconic meaning in sign language (see overview and disucssion in Goldin-Meadow and Brentari 2015). Based on a wide range of factors, including both semantic interpretation and temporal alignment, the general conclusion is that speech and gesture are part of an integrated system.

The utterence in (291) provides an example in which meaning from speech and gesture must be integrated; we infer that the fish was the size indicated by the accompanying gesture.

(291) I caught an enormous fish last week.
–size gesture–

In order to interpret such utterances, a person must combine two meanings that are presented in parallel—one through a linguistic mode, one through a pictorial mode.

Recent work has begun to investigate the semantic properties of the gesture-speech interface from a formal perspective (see Ebert and Ebert 2014, Schlenker ms.). From the point of view of semantic technology, representing multiple meanings in tandem requires no great innovation: multi-dimensional meanings have been proposed for phenomena such as focus (Rooth 1985) and conventional implicature (Potts 2007). The parallel goes further: just as focus-sensitive operators like *only* incorporate the focus alternatives into the regular semantic value, Ebert and Ebert (2014) observe that demonstrative expressions like *this wide* and *like so* incorporate gestural meaning into the regular semantic value. (In fact, the English degree modifier *yay* seems to be used exclusively in the presence of co-speech gesture.)

(292) I knew him when he was yay big.
–height gesture–

The interaction of speech and gesture, and its relation to iconicity in sign language, remains an open question.

[1] Another example: the attested headline in (290) describes a video from NBC news in which robots fall over a total of 17 times (contrasted with the three repetitions of *again*).

(290) Watch robots fall over again and again and again

Appendix: ASL judgment tokens on 7-point scale

	Report	Avg.	Sentence/judgment tokens						
(34)/(54)/(62b)	✓	7	1357b/1359 7	1388a/1389 7	1357b/1590 7	1519b/1520 7			
(35)/(47)/(74b)/(80b)	✓	7	1351b/1352 7	559b/560 7	1388b/1389 7	1351b/1591 7	559b/1605 7	1108d/1109 7	538a/539 7
(36)	✓	6.75	1355b/1356 6	545/546 7	1388c/1389 7	1355b/1592 7			
(37)/(67)	✓	7	1074b/1075 7	1074b/1602 7	1405/1406 7				
variants:		7	1386d/1387 7	1292b/1293 7					
(46)	✓	6.5	847b/848 6	847b/1593 7					
(48)	✓	7	571/572 7	571/1594 7	652b/653 7				
(56)/(104b)	✓	7	1287/1288 7	1287/1595 7	1358c/1360 7	see (58)–(60)			
(58)	✓	7	1090a/1091 7	1090a/1596 7	1209a/1210 7	1280a/1281 7			
(59)	✓	7	1090b/1091 7	1090b/1596 7	1209b/1210 7	1280b/1291 7			
(60a,b,c)	{✓,✓,✓}	{7,7,7}	1092/1093 {7,7,7}	1092/1180 {6,7,7}	1092/1597 {7,7,7}				
(61)		4.5	1185a/1186 6	1185a/1598 3					
∼(61) with context		7	1285a/1286 7	1285a/1599 7					

	Report	Avg.	Sentence/judgment tokens				
(62a)/(104a)	✓	7	1390a/1391 7	1390a/1600 7	1357a/1359 7		
(62c)	*	2.5	1390c/1391 2	1390c/1600 3			
(62d)/(104c)	*	2.5	1390d/1391 3	1390d/1600 2			
(63)	✓	7	1403/1404 7	1403/1601 7			
(71)		5.5	1074a/1075 5	1074a/1602 6			
(72)	✓	6.5	1072a/1073 7	1072a/1603 6			
variants:		7	1386a/1387 7	1292a/1293 7			
(73)	✓	7	257 ✓	257/1604 7	274/275 7		
(74a)/(80a)	✓	7	559a/560 7	559a/1605 7	1108a/1109 7		
(75a,b)	{✓,*}	{7,4}	550bd/ {7,4}	550bd/1606 {7,4}			
(81a,b)	{✓,*}	{6.5,3.5}	543/544 {6,3}	1110ad/1111 {6,2}	543/1273 {7,4}	543/1607 {7,5}	
(85)	✓	7	554/555 7	554/1608 7			
the reverse:		7	556/557 7	556/1609 7			
(86)	✓	7	1380/1381 7	1380/1610 7			
(87)	✓	7	1296b/1297 7	1296b/1611 7			
(88)	✓	7	1296a/1297 7	1296a/1611 7			
(96)	✓	7	1401a/1402 7	1401a/1612 7			
(97)	✓	6.5	1395/1396 6	1395/1613 7			
(107a,b,c)	{✓,*,*}	{7,3.6,2.7}	142cde/143 {7,3,4}	142cde/1614 {7,3,2}	1549/1550 {7,5,–}	1353b/1354 {–,3,–}	184bcd/186 {7,4,2}

	Report	Avg.	Sentence/judgment tokens			
DIE-{slow/bit-by-bit}	{✓,✓}	{6.5,7}	1145b,1148a/1146,1149 {5,7}	1145b,1148a/1236 {6,7}	1145b,1148a/1615 {7,7}	
			1470/1479 {7,7}	1311/text {7,7}	1500g,1502g/1501,1503 {7,7}	
ARRIVE-{slow/bit-by-bit}	{✓,✓}	{6.3,6.3}	1237bd/1238 {6,7}	1237bd/1616 {7,7}	1500e,1502e/1501,1503 {6,5}	
CHANGE-{slow/bit-by-bit}	{✓,✓}	{7,6.5}	1334cd/text {7,7}	1334cd/1618 {7,6}		
BUY-{slow/bit-by-bit}	{*,*}	{4.3,3.7}	1239bd/1240 {3/2}	1239bd/1617 {4/4}	1477bc/1479 {6/5}	
NOTICE-{slow/bit-by-bit}	{*,*}	{3,2}	1316cd/text {3,2}	1316cd/1619 {3,2}		
(229a) {rep.,rest.}	{✓,✓}	7	1374b/1375 7; {✓,✓}	1374b/1620 7; {*,✓}	1488a/1489 7; {✓,✓}	1506a/1507 7; {likely,poss.}
(229b) {rep.,rest.}	{✓,✓}	{7,7}	1458/1459 {7,7}	1458/1621 {7,7}		
(229c) {rep.,rest.}	{✓,✓}	{7,7}	1522cd/1523 {7,7}	1522cd/1622 {7,7}		
(229d) {rep.,rest.}	{✓,✓}	{7,7}	1537/1538 {7,7}	1537/1623 {7,7}		
(230)	✓	7	1376b/1377 7; (231a) and (b)	1376b/1624 7; only (231b)	1511a/1512 7; (231a) and (b)	
(261a,b)	{✓,✓}	{7,7}	1282/1283 {7,7}	1282/1625 {7,7}		
(263)	✓	6.5	1189/1190 6	1189/1626 7		
(265)	✓	7	1191/1192 7	1191/1627 7		
(266)	✓	7	1079/1080 7	1079/1628 7		
(267)	✓	7	1081/1082 7	1081/1629 7		
(286a,b)	{✓,✓}	{7,7}	1349/1350 {7,7} (global inf.)	1349/1630 {7,7} (global inf.)		

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