Handbook of Lexical Functional Grammar

Edited by

Mary Dalrymple

Empirically Oriented Theoretical Morphology and Syntax

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Chapter 1

Anaphora

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The LFG approach to anaphora explicitly recognizes the substantial amount of variation that we see attested in the grammar of anaphoric elements, and it offers a lexicalist account that captures this diversity. This chapter provides an overview of the major tenets of this approach. We discuss how LFG captures prominence relations between anaphors and antecedents, as well as the inventory of further constraints that determine the size of the binding domain and the search for an antecedent. The chapter includes a brief commentary on logophoric elements and on how the anaphoric dependency itself is represented in LFG accounts, and it concludes with an outlook on other pertinent issues addressed in the LFG literature.

1 Introduction

In the broader sense of the term, anaphora is a referential dependency relation between an ANTECEDENT and an ANAPHORIC ELEMENT, with the latter being dependent on the former for its interpretation. In (1), for example, the embedded subject *he* is in principle free to refer to any available singular discourse participant that matches the gender of the pronoun, but assuming topic continuity between the matrix and the subordinate clauses, the most likely interpretation is that the subordinate subject is anaphorically linked to the matrix subject.[1]

(1) He thought that *he* would catch a train up to London.

(2) My mother, *she* just entered a mysterious decline.

[1]Examples (1), (2) and (4) are from the British National Corpus (Davies 2004).

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In (2), the anaphoric link between the subject pronoun she and the left-dislocated noun phrase *my mother* is obligatory. But this is a property of the construction itself (see Haug forthcoming [this volume] on ANAPHORIC AGREEMENT of this sort), since the personal pronoun *she* is not constrained elsewhere to occur in the company of a linguistically expressed antecedent. Personal pronouns can in fact establish reference to discourse participants through a deictic pointing gesture, as happens in (3):

(3) Who did you mean? *Him* or *her* over there?

Thus personal pronouns are born free, even if they often end up bound to antecedents under particular linguistic circumstances.

Personal pronouns are unlike reciprocals or reflexives in this respect, which do normally require the presence of a linguistic antecedent. In the small discourse universe of (4), the subject pronoun *he* refers back to Graham, and the object pronoun *them* to the group of Slater and Sarah. This is a very likely interpretation, but one that is in principle not obligatory. The reciprocal *each other*, however, must be in a strict dependency with an antecedent, which is the object pronoun *them* in (4).

(4) Graham didn't mind Slater knowing about Sara – he had introduced them to *each other*, after all.

Likewise, the object reflexive *themselves* requires the availability of a local antecedent, the subject *these animals* in the case of (5).

(5) These animals protect *themselves* against being eaten by secreting poisonous substances.

Following the accepted practice of generative grammars, I will refer to reflexives and reciprocals as ANAPHORS in this chapter. The term ANAPHORIC ELEMENT is used here as a cover for anaphors and anaphorically interpreted personal pronouns.

An anaphor in this narrow, categorial sense is a referentially dependent type of pronominal expression, which cannot be used deictically and which requires the presence of a linguistically expressed antecedent. The primary aim of this chapter is to give an overview of what anaphoric phenomena have attracted attention in LFG-based research, and what discussions these phenomena have generated. The standard LFG approach to the grammar of anaphors has two major descriptive tenets. First, in line with the lexicalist nature of LFG, the constraints that govern the grammar of anaphoric elements are stated in their lexical entries. Whether these lexical constraints are comprehensive, and thus more or less fully specify the grammar of anaphors, or they are to be supplemented by what Belyaev forthcoming [this volume] calls GRAMMAR-WIDE CONSTRAINTS, is an issue where particular approaches may vary. Dalrymple (1993, 2001) and Dalrymple et al. (2019) postulate lexical entries that are rich enough in themselves, while Bresnan (2001) and Bresnan et al. (2016) emphasize the role of pertinent constraints that form part of the inventory of the universal design features of grammar. But this is partly a matter of perspective and emphasis, and in the lexicalist nature of LFG architecture, everything can be stated in the lexicon (evoking redundancy rules or templates where generalisations need to be captured). This chapter takes a comprehensive descriptive approach in presenting pertinent LFG research.

The second major tenet of the LFG approach to anaphora is the recognition that the distinction between anaphors and personal pronouns is not necessarily pronounced: neither empirical reasons, nor general theoretical concerns necessitate an approach in which anaphors and pronouns are considered to be two entirely distinct and discrete categories of grammar. Particular LFG descriptions may make use of a PRONTYPE attribute with values PERSONAL, REFLEXIVE or RECIPROCAL (as well as other pronominal types not relevant for us), but such features tend to play relatively little theoretical role in the actual analysis itself. Therefore, the term ANAPHOR is used here mostly for expository purposes only, with no specific theoretical commitment attached. One reason why the study of anaphoric systems has become a favourite topic of many researchers is exactly their versatile nature, and a major aim of this chapter is to demonstrate how the LFG architecture can be employed to describe this rich landscape adequately.

The structure of this chapter is as follows. In Section 2 and Section 3, I provide an overview of the standard LFG-theoretic approach to the binding of anaphors, discussing first the prominence relations between anaphors and their potential antecedents (Section 2), and then the constraints that determine the binding domain and the search for the antecedent (Section 3). In Section 4, I briefly discuss the LFG approach to discourse-dependent or logophoric elements. In Section 5, I make some comments on anaphor interpretation and on how the anaphoric dependency itself is represented in LFG accounts. Section 6 concludes this chapter.

2 Prominence relations and anaphora

2.1 Syntactic rank

One core property of anaphoric dependencies is that the antecedent needs to be more prominent than the anaphor *at some level of representation*. In Chomskyan generative approaches, the anaphor is required to have a c-commanding antecedent. The relation c-command is defined over hierarchical structures represented as trees, but LFG employs f-structure as the primary locus for capturing generalizations about abstract syntactic relations.[2] Thus, syntactic prominence relations are primarily described in terms of f-structure. This allows us to abstract away from attested variation in the surface coding of anaphoric dependencies in case such variation does not seem to correlate with grammatically relevant differences in how these dependencies are constructed. I illustrate the motivation for the LFG approach with parallel English and Hungarian data involving the reciprocal anaphor.

The triadic predicate *introduce* projects onto a syntactic structure in which the reciprocal anaphor may assume two syntactic functions: it is either the oblique PP argument (6a) or the object (6b), and it is ungrammatical as a subject (6c). The antecedent may either be the object or the subject argument in (6a), but if the reciprocal is the object, then only the subject can antecede it (6c):

(6) a. They$_i$ introduced the children$_k$ to *each other*$_{i/k}$.
b. They$_i$ introduced *each other*$_{i/*k}$ to the children$_k$.
c. **Each other* introduced them to the children.

This observed syntactic asymmetry between the anaphor and the antecedent is described as a difference in syntactic rank as defined by the Functional Hierarchy, which is independently needed in the description of other grammatical phenomena:[3]

(7) a. Functional Hierarchy (Bresnan et al. 2016: 229)

SUBJ > OBJ > OBJ$_\theta$ > OBL$_\theta$ > COMP, XCOMP > ADJ

b. Syntactic rank (Bresnan et al. 2016: 230)

[2] Several definitions of c-command exist; here we simply assume the textbook variety.

[3] This hierarchy has played an important role in LFG, and it has its predecessors and analogues in other frameworks; see, for example, the accessibility hierarchy of Keenan & Comrie (1977), or Pollard & Sag (1992).

> *A* locally outranks *B* if *A* and *B* belong to the same f-structure and *A* is more prominent than *B* on the functional hierarchy. *A* outranks *B* if *A* locally outranks some *C* which contains *B*.

An anaphor requires an antecedent which outranks it. Applying (7) to the data in (6), *B* is the anaphor *each other* and *A* is the antecedent, which is either the subject *they* or the object *the children* in (6a), or only the former in (6b). (6c) is out because, among other things, the reciprocal anaphor *each other* is the subject, and since the subject function is at the topmost position of the hierarchy, no outranking antecedent is available in the clause.[4]

The advantages of the f-structure-centered LFG approach to binding are especially apparent if we compare the English data in (6) to their counterparts in other languages, where clausal syntax is different. Hungarian is one such language. In particular, it allows for the pro-drop of subjects (treated as pronoun incorporation in LFG, see Toivonen forthcoming [this volume]), and it has a non-configurational VP.[5] Consequently, the Hungarian versions of (6a) may lack an overt subject, and the linear ordering of the constituents is also relatively free within the VP. (8a-8b) represent two discourse neutral configurations, and each has the same ambiguity in terms of antecedent choice that we have seen in the case of the English (6a).

(8) Hungarian

a. Bemutat-ták a gyerekek-et egymás-nak.
introduce-PST.3PL the children-ACC each.other-DAT
'They$_i$ introduced the children$_k$ to each other$_{i/k}$.'

b. Bemutat-ták egymás-nak a gyerekek-et.
introduce-PST.3PL each.other-DAT the children-ACC
'They$_i$ introduced the children$_k$ to each other$_{i/k}$.'

---

[4]This does not necessarily mean that *each other* cannot be a SUBJ, since it can be the subject of a subordinate clause under certain circumstances (see Lebeaux (1983: 724) for pertinent discussion). The following examples are from the British National Corpus (Davies 2004):

(i) We all read what *each other* had written, anyway.

(ii) One wonders how on earth they speak to each other, or if indeed they even know who *each other* is.

(iii) We all know how *each other* plays and that's why things are ticking.

The matrix antecedent outranks *each other* in these cases, too, according to (7), since the matrix SUBJ antecedent locally outranks the COMP that contains the subject anaphor.

[5]See Laczkó forthcoming [this volume] and Laczkó 2021 on the non-configurational nature of the Hungarian VP, and on pro-drop phenomena in Hungarian.

Disregarding empirical details that are irrelevant for the purposes of the current discussion (such as the fact that Hungarian employs dative case on the oblique anaphor instead of an adposition), the divergent English and Hungarian c-structures all map onto the same f-structure in (9).[6]

(9) f-structure of (6a) and (8a–8b)

$$
{}_{f}\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{introduce}\langle\textsc{subj}, \textsc{obj}, \textsc{obl}_{\textsc{to}}\rangle\text{’} \\
\textsc{tense} & \textsc{pst} \\
\textsc{subj} & {}_{g}\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{pro}_{i}\text{’} \\
\textsc{prontype} & \textsc{pers} \\
\textsc{pers} & 3 \\
\textsc{num} & \textsc{pl}
\end{array}\right] \\
\textsc{obj} & {}_{h}\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{children}_{k}\text{’} \\
\textsc{num} & \textsc{pl}
\end{array}\right] \\
\textsc{obl}_{\textsc{to}} & {}_{j}\left[\begin{array}{ll}
\textsc{pred} & \text{‘}\textsc{pro}_{i/k}\text{’} \\
\textsc{prontype} & \textsc{recip}
\end{array}\right]
\end{array}\right]
$$

Syntatic rank is a device that is used to describe variation in syntactic prominence as stated at the level of f-structure, and it is primarily at this level where elegant and universally relevant generalisations can be made about anaphoric phenomena. One such generalisation is that an anaphor needs an antecedent that outranks it in the sense of (7).[7]

Syntactic rank captures the most salient aspect of c-command, the arrangement of constituents along a hierarchy. Embedding configurations may create issues which may scope beyond what reference to syntactic rank transparently solves. For example, the potential antecedent cannot be embedded too deeply within the search domain of the anaphor, hence the ungrammaticality of (10).

(10) *The children$_i$'s mother washed themselves$_i$.

[6]No INDEX features (PERS and NUM) are specified for the reciprocal anaphor in the f-structure *j* in (9). We provide an overview of the LFG treatment of the feature content of anaphoric elements in Section 5.

[7]Note that the antecedent in (9) locally outranks the anaphor since both are members of the same f-structure *f*. By (7b), this relation need not be local, and it is not always local in the case of other types of anaphors that we discuss in Section 3. See also footnote 4.

(11)
$$
f\left[\begin{array}{ll}
\textsc{pred} & \text{`}\textsc{wash}\langle\textsc{subj}, \textsc{obj}\rangle\text{'}\\
\textsc{tense} & \textsc{pst}\\
\textsc{subj} & g\left[\begin{array}{ll}
\textsc{poss} & i\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{child}\text{'}\\ \textsc{num} & \textsc{pl}\end{array}\right]\\
\textsc{pred} & \text{`}\textsc{mother}\text{'}\\
\textsc{num} & \textsc{sg}
\end{array}\right]\\
\textsc{obj} & j\left[\begin{array}{ll}
\textsc{pred} & \text{`}\textsc{pro}\text{'}\\
\textsc{prontype} & \textsc{refl}\\
\textsc{index} & k\left[\begin{array}{ll}\textsc{pers} & 3\\ \textsc{num} & \textsc{pl}\end{array}\right]
\end{array}\right]
\end{array}\right]
$$

The plural reflexive anaphor *themselves* can only take a plural antecedent. The plural possessor *the children* could in principle act as one, but since it is properly contained within the possessive structure of the subject (f-structure *i* is in f-structure *g*), it cannot license the anaphor and therefore sentence (10) fails. LFG employs the notion of f-command to constrain such scenarios.[8]

(12) F-command (Dalrymple et al. 2019: 238)

f f-commands *g* if and only if *f* does not contain *g*, and all f-structures that contain *f* also contain *g*.

The English reflexive anaphor *themselves* needs an f-commanding antecedent that outranks it. F-structure *g* f-commands f-structure *j* in (11), but since *g* is a singular noun phrase, it does not match the INDEX features of the anaphor (see Section 5). F-structure *i* is plural and could thus be a potential antecedent for the reflexive, but it does not f-command it: one f-structure that contains *i*, namely f-structure *g*, does not contain the f-structure of the anaphor, *j*. Therefore the noun phrase *the children* does not f-command the reflexive anaphor *themselves*, and (10) is ungrammatical.

While f-command is a universal requirement on anaphor licensing, there still are anaphors in some languages that may take non-f-commanding antecedents under certain circumstances. We discuss here two reflexives to illustrate this phenomena. The antecedent of the Icelandic reflexive *sig* or the Mandarin reflexive *ziji*, for example, can be an embedded human possessor under the right discourse conditions. The Icelandic example (13a) describes Sigga's opinion, and the embedded clause, which includes the anaphor, is interpreted in her model of the

[8]As Dalrymple et al. (2019: 239) discuss, a more complex definition of f-command is required to cover constructions that involve structure-sharing dependencies. Those concerns are not directly relevant for us now, and (12) suffices for our purposes.

world. The anaphor is thus tied to an antecedent who is a perspective holder, and this saves the configuration even if f-command is not satisfied (and even if the antecedent and the anaphor are not in the same clause). Since the embedded possessor (*Olaf*) is not a perspective holder in the case of (13b), the reflexive is unacceptable there.

(13) Icelandic (Maling 1984: 220–222)

a. Skoðun Siggui er að *sig* vanti hæfileika.
opinion Sigga's is that self.ACC lacks.SBJV talent
'Sigga$_i$'s opinion is that she$_i$ lacks talent.'

b. *Trú Ólafs á guð bjargaði *sér*.
belief Olaf$_i$'s in god saved self.DAT
'Olaf's$_i$ belief in god saved him$_i$.'

As is expected, the possessor cannot be an inanimate noun phrase in examples of this kind, since inanimate entities do not have mental states. Charnavel & Huang (2018) explicitly show that inanimate possessors are degraded in this construction in Mandarin (14b), even if they are claimed to be able to antecede *ziji* elsewhere (see Lam 2021 for a discussion and for further data on *ziji* with an antecedent embedded in the subject). But (14a) is a description of the mental state of the antecedent, Zhangsan, and this is apparently enough to license the anaphor even in the absence of f-command.

(14) Mandarin (a: Tang 1989: 100, b: Charnavel & Huang 2018: 140)

a. Zhangsan de jiaoao hai-le ziji.
Zhangsan DE pride hurt.ASP self
'Zhangsan$_i$'s pride harmed him$_i$.'

b. *Zhe ke shu de guoshi ya wan le ziji.
this CL tree DE fruit press bent ASP self
'The fruits of this tree$_i$ bent it$_i$.'

We discuss the role of point of view in the licensing of certain types of anaphora in Section 4. What the above data in (13) and (14) illustrate is that human or animate possessors in some languages can gain the kind of prominence that allows them to license anaphors even when the f-command relation between antecedent and anaphor is not satisfied.[9]

[9] Bresnan et al. (2016: 268) offer an LFG analysis of the Icelandic construction in (13a) that includes the postulation of an f-command relation between the possessor and the embedded reflexive subject. For a recent LFG approach to the Mandarin data, see Lam (2021).

I discuss the LFG approach to domain restrictions on anaphora in Section 3. But before we turn to that, I briefly review anaphoric data where syntactic rank in the sense as we have discussed this notion here, does not seem to be the dominant factor in the search for a prominent antecedent.

2.2 Thematic prominence

Certain anaphors or anaphoric dependencies are constrained by factors that are at least partially independent of syntactic rank. Argument structure relations represent one such factor. If, for example, both the antecedent and the anaphor are oblique arguments of the same predicate, then they are indistinguishable with respect to the Functional Hierarchy in (7a). Dalrymple (1993: 154) discusses the following minimal pair, where the complement of the *to*-PP can antecede the complement of the *about*-PP, but not vice versa (see also Pollard & Sag 1992: 266):

(15) a. Mary talked to John$_i$ about *himself*$_i$.
  b. *Mary talked about John$_i$ to *himself*$_i$.

This binding asymmetry can be described with reference to a hierarchy among argument roles, like that of the Thematic Hierarchy of Bresnan & Kanerva (1989) in (17), under the assumption that the *to*-PP bears a type of recipient role in (15), while the *about*-PP is a theme.

(16) Thematic Hierarchy (Bresnan & Kanerva 1989)

AGENT > BENEFACTIVE > RECIPIENT/EXPERIENCER > INSTRUMENT > THEME/PATIENT > LOCATIVE

What rules (15b) out is that the antecedent PP *about John* is less prominent thematically than the anaphoric PP *to himself*. This is because THEME is lower on the hierarchy than RECIPIENT. The Functional Hierarchy, in and of itself, cannot capture this difference, since both PP's are obliques in the f-structure of the sentence.

One potential counterargument to this understanding of the data in (15) is to deny the argumenthood of the *about*-PP. If it is an adjunct, as Reinhart & Reuland (1993: 715) argue, then syntactic rank suffices to explain the ungrammaticality of (15b), since an adjunct PP is less prominent than an oblique on the Functional Hierarchy, and therefore the former cannot antecede the latter. Similar concerns may arise with other predicates that take two PP dependents, since it is often the case that one can find reasons to assume that one of the two PP's is less argument-like than the other.[10]

But reference to the thematic hierarchy may still be necessary elsewhere. Dalrymple (1993: 153) discusses the following Norwegian data set (citing Hellan 1988) as a relevant case. Norwegian ditransitive verbs allow either of their two VP-internal objects to become subjects in the passive construction. (17b) illustrates the version where the recipient is the passive subject, and (17c) has the theme in the same function.

(17) Norwegian (Hellan 1988: 162)
  a. Vi overlot Jon pengene.
     we gave Jon money
     'We gave John the money.'
  b. Jon ble overlatt pengene.
     Jon was given money
     'John was given the money.'
  c. Pengene ble overlatt Jon.
     money was given Jon
     'The money was given to John.'

Norwegian has a dedicated reflexive possessor, *sin*. Interestingly, when the object contains this reflexive, as in (18), then only one of the two potential readings of the passive sentence is acceptable. It is reading (i) below, which includes the malefactive subject argument binding the reflexive in the theme object. We assume that malefactives and benefactives occupy the same position on the Thematic Hierarchy.

(18) Norwegian (Hellan 1988)
  Barnet ble fratatt sine foreldre.
  child was taken self parents
  (i) 'The child was deprived of self's parents.' MALEFACTIVE > THEME
  (ii) *'The child was taken away from self's parents.'
  THEME > MALEFACTIVE

Reading (ii) would have the theme subject binding into the malefactive object, or in other words, a thematically less prominent antecedent binding into a more prominent one. Reference to the Thematic Hierarchy is thus essential here to be able to distinguish between the acceptable and the unacceptable reading of (18).

[10] Zaenen & Crouch (2009) argue on the basis of computational efficiency that semantically marked optional PPs are best treated as adjuncts.

2.3 Linear order

Anaphoric relations are sometimes constrained by linear order, inasmuch as the anaphor may be required to have an antecedent that precedes it linearly. Linear order thus represents another dimension of prominence relations relevant in the description of binding phenomena. Facts concerning the linear order of constituents are captured at the level of c-structure in the LFG architecture, and given the f-structure centered nature of LFG, such facts need to be addressed separately.

Consider the following Hungarian data set for the purposes of illustration (É. Kiss 2008). Binding among co-arguments is primarily constrained by the Functional Hierarchy in Hungarian, so the object can bind the oblique argument (19a), but the oblique cannot bind the object (19b).

(19) Hungarian (É. Kiss 2008: 451)

a. Meg-kérdeztem a fiúk-at egymás-ról.
   PFV-asked.1SG the boys-ACC each.other-about
   'I asked the boys about each other.'

b. *Meg-kérdeztem a fiúk-ról egymás-t.
   PFV-asked.1SG the boys-about each.other-ACC
   ('I asked each other$_i$ about the boys$_i$.')

É. Kiss notes, however, that linear order plays an important role in the case of non-coargument binding: when the antecedent precedes the anaphor embedded in another argument of the verb, then the acceptability of the anaphor improves significantly, even if the antecedent ranks lower on the Functional Hierarchy.

In (20a), the object locally outranks the oblique antecedent, and therefore the reciprocal possessor embedded in the object cannot be bound. But when the oblique antecedent linearly precedes the object, as happens in (20b-20d), then the sentence becomes much less degraded (and in fact, many speakers find these examples fully acceptable).

(20) Hungarian (É. Kiss 2008: 452)

a. *Meg-kérdeztem egymás szülei-t a fiúk-ról.
   PFV-asked.1SG each.other parents.POSS-ACC the boys-about
   ('I asked each other$_i$'s parents about the boys$_i$.')

b. ?A fiúk-ról egymás szülei-t kérdeztem meg.
   the boys-about each.other parents.POSS-ACC asked.1SG PFV
   'About the boys$_i$, I asked each other$_i$'s parents.'

c. ?A fiúk-ról meg-kérdeztem egymás szülei-t.
the boys-about PFV-asked.1SG each.other parents.POSS-ACC

d. ?Meg-kérdeztem a fiúk-ról egymás szülei-t
PFV-asked.1SG the boys-about each.other parents.POSS-ACC

Thus changes in the linear order save this sort of binding dependency. In other words, both syntactic rank and linear order play a role in constraining non-coargument binding in Hungarian, but the linear order constraint apparently outranks the syntactic rank constraint imposed on the antecedent.[11]

In the LFG literature, Bresnan et al. (2016) provide a comprehensive discussion of the role of linear precedence in conditioning pronominal anaphoric dependencies (see also Belyaev forthcoming [this volume]). Mohanan (1982) shows that overt pronouns cannot precede their antecedent in Malayalam, and Kameyama (1985) discusses pertinent Japanese data. In order to be able to capture these and other phenomena sensitive to linear order, LFG relies on the notion of f-precedence, which Kaplan & Zaenen (1989) define as follows:

(21) f f-precedes g ($f <_f g$) if and only if for all $n1 \in \phi^{-1}(f)$ and for all $n2 \in \phi^{-1}(g)$, $n1$ c-precedes $n2$.

The usual flow of information in the correspondence architecture of LFG is from c-structure to f-structure. The relation ϕ^{-1} provides for the inverse correspondence from f-structure to c-structure: it associates f-structures with the c-structures nodes they correspond to. The term $n1 \in \phi^{-1}(f)$ identifies the set of c-structure nodes that correspond to the f-structure f. The definition in (21) thus states that f-structure f f-precedes f-structure g if and only if all the c-structure nodes corresponding to f c-precede all the c-structure nodes corresponding to g. The relation C-PRECEDENCE can be defined as follows:[12]

(22) C-precedence

A c-structure node $n1$ c-precedes a node $n2$ if and only if $n1$ does not dominate $n2$, $n2$ does not dominate $n1$, and the string that $n1$ dominates (or $n1$ if $n1$ is itself a terminal) precedes the string that $n2$ dominates (or $n2$ if $n2$ is itself a terminal).

[11] In addition, the antecedent must also f-command the anaphor. This requirement is satisfied in each example in (20).

[12] I thank an anonymous reviewer of this paper and Mary Dalrymple for their help in constructing the definition in (22). By *precede* we simply mean 'be to the left of' in the string.

F-precedence allows us to make reference to linear ordering facts at the level of f-structure, the locus where binding dependencies are primarily constrained in LFG. It relies on the notion of the inverse correspondence from f-structure to c-structure, which is evoked as a somewhat marked feature of the grammatical model. But this only reflects the fact that while conditioning anaphoric dependencies by linear order is an existing pattern in languages, it is not the dominant mode of licensing anaphors.

3 Constraining binding domains

The comprehensive description of a binding relation includes several components, which are stated in terms of f-structural properties in LFG. Anaphors require an antecedent that is available within a particular binding domain. The antecedent and the anaphor need to have matching agreement features, and antecedents are often constrained to be of specific types. For example, some anaphors require a subject antecedent, while others may need an antecedent that is a perspective holder. And, as we have seen in Section 2, the antecedent must be more prominent than the anaphor, which, by default, means that the antecedent f-commands the anaphor as well as outranks it on the Functional Hierarchy. Dalrymple (1993) proposed that these binding constraints are lexically specified on the anaphors, and there is a universally available inventory of them. Dalrymple (2001), Dalrymple et al. (2019), Bresnan (2001), and Bresnan et al. (2016), among others, extend this line of research, which I briefly overview in this section, adding some complementary remarks in Section 4 and Section 5. What lies at the heart of the LFG approach is that the grammatical space that anaphors occupy is too rich to be described in terms of generalizations of the type that classical Principle A represents. Anaphors vary along the parameters summarized above both across languages, and possibly within a single language. This versatility must be captured in any adequate description of anaphoric phenomena.

The core underlying assumption is that anaphors find or search for an antecedent within a specified domain. Inside-out functional uncertainty is used to model this search, since it allows reference to enclosing structures.[13] (23) is the general formula employed in the lexical description of binding dependencies:

[13]See Belyaev forthcoming [this volume] for an overview discussion of inside-out function application and functional uncertainty, as well as for references to pertinent LFG literature. Strahan (2009, 2011) develops a proposal in which the search is inverted: the antecedent searches for the anaphor using outside-in functional uncertainty.

(23) $((\textsc{gf}^{*}\ \textsc{gf}_{\textsc{pro}}\ \uparrow)\ \textsc{gf}_{\textsc{ant}})$

$\textsc{gf}_{\textsc{ant}}$ is the grammatical function of the antecedent, and $\textsc{gf}_{\textsc{pro}}$ is the grammatical function of the anaphoric element.[14] The expression $\textsc{gf}^{*}\ \textsc{gf}_{\textsc{pro}}\uparrow$ defines a path from the f-structure of the anaphoric element to an f-structure that contains the antecedent.[15] In terms of a schematic f-structure, (23) describes the following scenario:

(24) $${}_{f}\left[\begin{array}{ll} \textsc{gf}_{\textsc{ant}} & {}_{g}\left[\textsc{antecedent}\right] \\ ...\textsc{gf}^{*}... & \left[\textsc{gf}_{\textsc{pro}}\ {}_{j}\left[\textsc{anaphor}\right]\right] \end{array}\right]$$

Here $\textsc{gf}^{*}\ \textsc{gf}_{\textsc{pro}}\uparrow$ defines a path from f-structure j to f-structure f, which contains the antecedent (f-structure g).

(23) requires the f-structure of the antecedent to f-command the anaphor (compare 12 and 23). In addition, further prominence relations can be stated in terms of off-path constraints on the f-structure of the antecedent. These include the prominence relations we have surveyed in Section 2: relations defined over the Functional Hierarchy or the Thematic Hierarchy, or linear order constraints. Dalrymple et al. (2019: 516–517) offer a discussion of how such constraints can be implemented, here I simply indicate the availability of this tool by adding a generic prominence template as an off-path constraint, which is meant to represent different types of prominence descriptions as is relevant for the anaphor.

(25) $((\ \textsc{gf}^{*}\ \textsc{gf}_{\textsc{pro}}\ \uparrow)\ \underset{@\textsc{prominent}}{\textsc{gf}_{\textsc{ant}}}\ )$

Such an off-path constraint requires the antecedent to be more prominent than the anaphor along one or more of the dimensions discussed here.

Anaphors may also impose further specific requirements on their antecedents. They may require them, for example, to be subjects (see Bresnan et al. 2016 and Dalrymple et al. 2019 for pertinent discussions). The Norwegian reflexive possessor *sin* can only be bound by the subject (26a), but not by the object (26b):

(26) Norwegian (Dalrymple et al. 2019: 510, citing Hellan 1988: 75)

a. Jon ble arrestert i sin kjøkkenhave.
Jon was arrested in self's kitchen.garden
'Jon$_i$ was arrested in his$_i$ kitchen garden.'

[14](23) is in fact applicable to any anaphoric element, be it a reflexive or a reciprocal anaphor proper, or an anaphorically used personal pronoun.

[15]This path may consist of a single attribute only.

b. *Vi arresterte Jon i sin kjøkkenhave.
We arrested Jon in self's kitchen.garden
'We arrested Jon$_i$ in his$_i$ kitchen garden.'

This can be stated simply by constraining the antecedent to be a SUBJ in the (partial) lexical specification of the reflexive possessor *sin*:

(27) ((GF* GF$_{\text{PRO}}$ ↑) SUBJ)

The Mandarin Chinese anaphor *ziji* has also been claimed to show subject orientation, and thus (27) is part of its lexical specification (see Lam 2021 for further details):[16]

(28) Mandarin Chinese (Pollard & Xue 1998: 296)
Zhangsan gei-le Lisi yi-zhang ziji de xiangpian.
Zhangsan give-ASP Lisi one-CL self DE picture
'Zhangsan$_i$ gave Lisi$_k$ a picture of himself$_{i/*k}$.'

In contrast, the Norwegian anaphor *ham selv* can only be bound by a non-subject argument, compare (29a) with (29b).

(29) Norwegian (Dalrymple 1993: 29–30)
a. Jeg ga Jon en bok om ham selv.
I gave Jon a book about him self
'I gave Jon$_i$ a book about himself$_i$.'
b. *Jon snakker om ham selv.
Jon talks about him self.
'Jon$_i$ talks about himself$_i$.'

The anti-subject orientation of ham selv can be stated as a negative constraint in the lexical entry of this anaphor: the antecedent cannot be a SUBJ.

The final component of the description of anaphoric dependencies, and the one that has received most attention in LFG since the seminal work of Dalrymple (1993), is the delimitation of the binding domain. Four such domains have been found to be relevant in the description of anaphoric binding, which are listed in (30). These domains can be defined with the help of inside-out functional designators and appropriate off-path constraints, which are also added in (30) below (Dalrymple et al. 2019: 507).

[16] In addition, *ziji* can also be bound by an antecedent properly contained in the subject, and it is sensitive to logophoricity (see Lam 2021, as well as example (14) above). We discuss logophoricity in Section 4.

(30) a. Coargument Domain: minimal domain defined by a PRED and the grammatical functions it governs

$$(\underset{\neg(\rightarrow \text{PRED})}{\text{GF}^*}\ \text{GF}_{\text{PRO}}\uparrow)$$

b. Minimal Complete Nucleus: minimal domain with a SUBJ function

$$(\underset{\neg(\rightarrow \text{SUBJ})}{\text{GF}^*}\ \text{GF}_{\text{PRO}}\uparrow)$$

c. Minimal Finite Domain: minimal domain with a TENSE attribute

$$(\underset{\neg(\rightarrow \text{TENSE})}{\text{GF}^*}\ \text{GF}_{\text{PRO}}\uparrow)$$

d. Root domain: f-structure of the entire sentence

$$(\text{GF}^*\ \text{GF}_{\text{PRO}}\uparrow)$$

These domain specifications are stated in the lexical entries of anaphors as either POSITIVE or NEGATIVE binding requirements. A positive binding constraint requires the anaphor to be in a binding relation with some entry within the domain described (subject to further constraints, as discussed above), whereas a negative binding constraint states that the anaphor must not be bound to any element within that domain. Positive and negative binding constraints take the following general forms:[17]

(31) a. Positive binding constraint

$$(\uparrow \text{ANTECEDENT})_\sigma = ((\text{GF}^*\ \text{GF}_{\text{PRO}}\uparrow)\ \text{GF}_{\text{ANT}})_\sigma$$

b. Negative binding constraint

$$(\uparrow \text{ANTECEDENT})_\sigma \neq ((\text{GF}^*\ \text{GF}_{\text{PRO}}\uparrow)\ \text{GF}_{\text{ANT}})_\sigma$$

In what follows, we discuss some examples to show how this system of lexical specifications works. Further and more comprehensive discussions can be found in Dalrymple (1993), Dalrymple et al. (2019) and Bresnan (2001).

The Norwegian complex anaphor *seg selv* is described in Hellan (1988) and Dalrymple (1993) as a subject oriented anaphor that requires a co-argument binder. And while Lødrup forthcoming [this volume] shows that speakers may also accept object binders in some cases, the co-argument binder requirement seems to be strong. The contrast between the following two examples illustrates this:

[17] Identity is stated between the semantic representations of the antecedent and the anaphor. The σ-projection provides the mapping from f-structure to the LFG-type s(emantic)-structure; see Section 5 for more on this.

(32) Norwegian (Dalrymple et al. 2019: 505–506, citing Hellan 1988: 67, 69)

a. Jon fortalte meg om *seg selv*.
   Jon told me about REFL self.
   'Jon$_i$ talks about himself$_i$.'

b. **Hun* kastet meg fra *seg selv*.
   she threw me from REFL self.
   'She$_i$ threw me away from self$_i$.'

The difference between the two constructions is that (32b) contains a semantic preposition with a PRED feature, while the oblique PP in (32a) does not.

Consider the f-structure of the grammatical (32a) first. The Coargument Domain constraint (30a) requires a path from f-structure j to the f-structure that contains the SUBJ antecedent. Since this is a short path, no PRED feature occurs on the way, and therefore the off-path constraint $\neg(\rightarrow \text{PRED})$ is satisfied. (33) is the (simplified) f-structure of (32a):

(33) f-structure of (32a)

$$f\left[\begin{array}{ll} \text{PRED} & \text{`TELL}\langle\text{SUBJ, OBJ, OBL}_{\text{ABOUT}}\rangle\text{'} \\ \text{SUBJ} & g\left[\text{PRED}\ \ \text{`JON}_i\text{'}\right] \\ \text{OBJ} & \left[\text{PRED}\ \ \text{`PRO'}\right] \\ \text{OBL}_{\text{ABOUT}} & j\left[\begin{array}{ll} \text{PRED} & \text{`PRO}_i\text{'} \\ \text{PRONTYPE} & \text{REFL} \end{array}\right] \end{array}\right]$$

In contrast, (32b) projects a more complex f-structure, with a more complex domain path:[18]

(34) f-structure of (32b)

$$f\left[\begin{array}{ll} \text{PRED} & \text{`THROW}\langle\text{SUBJ, OBJ}\rangle\text{'} \\ \text{SUBJ} & g\left[\text{PRED}\ \ \text{`PRO}_i\text{'}\right] \\ \text{OBJ} & \left[\text{PRED}\ \ \text{`PRO'}\right] \\ \text{ADJUNCT} & \left\{ j\left[\begin{array}{ll} \text{PRED} & \text{`FROM}\langle\text{OBJ}\rangle\text{'} \\ \text{OBJ} & k\left[\text{PRONTYPE}\ \ \text{REFL}\right] \end{array}\right] \right\} \end{array}\right]$$

Here the domain path starts at f-structure k, and to reach the f-structure of the antecedent, we need to pass the PRED feature in j – a move that the off-path constraint $\neg(\rightarrow \text{PRED})$ prohibits. As a result, (32b) is ungrammatical.

[18] The PP *fra seg selv* 'from self' could alternatively be analyzed as an OBL, but the choice between the ADJ and the OBL analysis is largely orthogonal to our current concerns. See also footnote 10 on this issue.

The primary Hungarian reflexive, *maga*, is grammatical in non-selected spatial PPs. In fact, it is often the only option in standard Hungarian, and a pronominal PP is unacceptable in the particular case of the Hungarian version of (32b) (Rákosi 2010).

(35) Hungarian

a. János$_i$ el-tolt engem magá-tól$_i$.
János away-pushed.3SG me himself-from
'János$_i$ pushed me away from himself$_i$.'

b. *János$_i$ el-tolt engem (ő$_i$-)től-e$_i$.
János away-pushed.3SG me he-from-3SG
'János$_i$ pushed me away from him$_i$.'

The source marker corresponding to the English preposition *from* is expressed as ablative case morphology in Hungarian (*-tól/-től*). Reflexives behave like lexical nouns in this respect, and they take the ablative case suffix as expected (35a). Personal pronouns, however, trigger agreement morphology on the case marker, and the pronoun itself is usually pro-dropped (36b). But whether this pronoun is overt or is pro-dropped, it cannot have a clause-mate antecedent, resulting in the ungrammaticality of (35b).

(35a) is thus in direct contrast with (32b). The Hungarian reflexive *maga*, unlike Norwegian *seg selv*, is subject to the Minimal Complete Nucleus constraint: it has to be bound within a domain that includes a subject. This is captured in (30b) with the help of the off-path constraint ¬(→ SUBJ). The f-structure of (35a) is analogous to (34), and using that f-structure for the purposes of illustration, the relevant domain path in Hungarian would take us from the f-structure of the reflexive (k) to f-structure j of the adjunct PP, which is contained within the matrix f-structure f, together with the subject antecedent g. Subject g can serve as the antecedent of the reflexive. Being subject to the Minimal Nucleus Constraint requires this search not to pass a subject antecedent, and it follows that Hungarian *maga* cannot take antecedents that are in another clause.

Interestingly, the Hungarian reciprocal anaphor *egymás* is somewhat freer than the reflexive *maga*, as it can take antecedents from within the Minimal Finite Domain. Compare the following two sentences:

(36) Hungarian (Laczkó & Rákosi 2019: 153)

a. A fiúk látták a lányok-kat lerajzol-ni maguk-at.
the boys saw.3PL the girls-ACC draw-INF themselves-ACC
'The boys$_i$ saw the girls$_k$ draw (a picture of) themselves$_{*i/k}$.'

b. A fiúk látták a lányok-kat lerajzol-ni egymás-t.
the boys saw.3PL the girls-ACC draw-INF each.other-ACC
'The boys$_i$ saw the girls$_k$ draw (a picture of) each other$_{i/k}$.'

The reflexive object of the infinitive can only be co-construed with the infinitival subject (controlled by the matrix object), but it cannot take the matrix subject as its antecedent in (36a). It is thus unlike the reciprocal in (36b), which can.

The Norwegian reflexive *seg selv*, the Hungarian reflexive *maga*, and the Hungarian reciprocal *egymás* are all anaphors, yet the binding constraints that apply to them are different. *Seg selv* needs an antecedent in the Coargument Domain, *maga* takes one from the Minimal Complete Nucleus, and *egymás* may have an antecedent even outside of its own embedding clause as long as the search is confined to the Minimal Finite Domain. In fact, the binding constraints that we have discussed in this section create a relatively large space within which particular lexical types of anaphors may vary, and research in the framework of LFG has shown that this space is indeed occupied by an abundance of anaphoric elements attested cross-linguistically. The list includes such relatively atypical anaphors as the ìı pronouns of Yạg Dii, which must take long distance antecedents (Dalrymple 2015) within a logophoric domain. We discuss logophoricity and these pronouns in Section 4 below.

4 Logophoricity

Anaphors, especially reflexives, may sometimes appear without a clause- or a sentence-mate antecedent, or even in the complete absence of a linguistically expressed antecedent. The following BNC (Davies 2004) examples contain such reflexives.

(37) a. And suddenly Briant felt better. These people were professionals, like *himself*.

b. I've not done this before and I wanted to try it out with a small group like *yourselves* to see how we go on with it.

c. Our group consisted of Stephen, David, Laura and *myself*, and we were aged twenty-two.

d. Lots of love to Birgitta and *yourself*, and to the boys when you see them.

One hallmark of these types of reflexives is that they are more or less freely exchangeable with personal pronouns. Thus, for example, *himself* in (37a) can be replaced with *him*, and both will refer to Briant in the given context.

Many instances of such types of anaphora have been claimed to be conditioned by discourse factors (see Maling 1984, Sells 1987, Pollard & Sag 1992, Reinhart & Reuland 1993, Culy 1994, and Bresnan et al. 2016, among others). The most prominent of these factors is perspective or viewpoint, in the sense that the (discourse) antecedent of the reflexives is a perspective holder. The reflexive in (37a), for example, occurs in a discourse context in which the feelings of Briant are described, and (37c) projects the speaker's perspective and hence creates a context in which the reflexive *myself* is licensed in the absence of a linguistically expressed antecedent. From a purely syntactic perspective, anaphoric data of this type are often approached as exceptional (see the term EXEMPT ANAPHORA in Pollard & Sag 1992). Pertinent research in LFG has focused on anaphoric elements which, unlike the English reflexive, must take a linguistically expressed antecedent which is a perspective holder. Such anaphoric elements are called LOGOPHORS.[19]

Bresnan et al. (2016) offer an in-depth discussion of logophoricity, including its relation to subjectivity. A logophoric pronoun "refers to one whose speech, thoughts, or feelings are represented in indirect discourse, from that person's own point of view" (Bresnan 2016: 255). They treat the Icelandic reflexive *sig* as a logophoric element (see also Maling 1984, as well as Strahan (2009, 2011)), and Lam (2021) provides a logophoric LFG-analysis of the Mandarin Chinese reflexive *ziji*, as well as of the Cantonese reflexive *jighei* (see also Pollard & Xue 1998 on the nonsyntactic uses of *ziji*). A very intriguing type of a logophoric pronominal is discussed in Dalrymple (2015). The Yąg Dii language (Niger-Congo/Adamawa-Ubangi, Cameroon) has a complex pronominal system that includes the *ìı* pronouns. These pronouns are like regular anaphors inasmuch as they cannot be used deictically, and they cannot take discourse antecedents. However, "the antecedent of *ìı* must be the subject of a clause that is at least two clauses distant" (Dalrymple 2015: 1090). In example (38), this pronoun is the subject of the embedded clause S3, and it must be co-construed with the subject of the matrix clause S1.

(38) Yąg Dii (Dalrymple 2015: 1091)

$_{S1}$[Àkàw	∅	ọ̀	$_{S2}$[lig	$_{S3}$[bà	ìi	lá	hẹn	lálɨ́ páskà
Teacher$_i$	(he$_i$)	say	house	that	he.ìi$_{i/*j}$	eat	thing	eating Easter

[19]Most of the pertinent research both within and outside of LFG has focused on reflexives, but, as Pollard & Sag (1992) point out, reciprocal anaphors may also be exempt. Szűcs (2019) discusses complex event nominalization data from Hungarian to show that Hungarian reciprocals embedded in such noun phrases may lack a linguistic antecedent and are then licensed as logophors.

kan waa duulí bìì vʉ wʉlɨ́ máa] bà dɨ tɛ́lá?]"
with child following his$_i$ PL there when, that.it is.there where?"
'$_{S1}$[The teacher$_i$ asks, $_{S2}$[where is the house $_{S3}$[in which he.ìi$_{i/*j}$ will eat the Easter meal with his$_i$ disciples?]]]

The antecedent subject must be a perspective holder, and the intermediate subject in *S*2 may or may not be coreferential with the pronoun as long as it does not introduce an independent logophoric domain.

Disregarding now details that are irrelevant for our purposes, the binding constraints on this pronoun can be stated as follows:

(39) Binding constraints for *ìı* (Dalrymple 2015: 1117)

$$(\uparrow_\sigma \text{ ANTECEDENT}) = ((\underset{(\rightarrow \text{ LOG})}{\text{GF}_{\text{LOG}}} \quad \underset{\neg(\rightarrow \text{ LOG})}{\text{GF}^*} \quad \uparrow) \text{ SUBJ})_\sigma$$

This lexical specification requires the pronoun to take a subject antecedent from an f-structure where a logophoric domain is specified, and the domain path needs to include an intermediate f-structure where no independent logophoric domain is introduced. Formally, the LOG feature appears within the f-structure that corresponds to the logophoric domain:

(40) $$_{S1}\left[\begin{array}{ll} \text{SUBJ} & \left[\text{LOGOPHORIC ANTECEDENT}\right] \\ \text{GF}_{\text{LOG}} & _{S2}\left[\begin{array}{l} \text{LOG} \;\; + \\ _{S3}\left[\ldots\text{ÌI}\ldots\right] \end{array}\right] \end{array}\right]$$

Yąg Dii thus has a pronominal system where logophoricity is a grammaticised notion, and it must be employed as an f-structure feature LOG in the determination of the binding domain. In the particular case of the logophor *ìı*, this domain must be unusually large as it must include an extra clause between the clause that hosts the antecedent and the clause that hosts the logophor.

5 On representing referential dependencies

Anaphoric dependencies may be represented via referential indices. These can be used in the f-structures themselves, a practice which I have followed in this chapter. The indices themselves do not form an integral part of the formalism, however, they are mere mnemonics that help visualize the dependency. The machinery that we have introduced in Section 3 allows us to represent such dependencies in a more elegant manner. The notation, in the tradition of Dalrymple

(1993), states that the semantic structure of the antecedent and of the anaphoric element are equivalent. The following is an abbreviation for the binding constraints on the basis of Asudeh (2019), where f is the f-structure of the anaphor and f_σ is its semantic structure (see Asudeh forthcoming [this volume] for semantic structure in LFG).

(41) $(f\ \textsc{antecedent})_\sigma = f_\sigma$

As Asudeh (2019) argues, this notation has several theoretical advantages over the referential index notation. Firstly and most importantly, it shifts attention to semantic structure, which is the appropriate place to represent referential dependencies.

The postulation of semantic equivalence between anaphor and antecedent abstracts away from the issue that it is often the case that no strict referential identity is required between the two. In (42), for example, the anaphor stands for the image of Kate in the mirror, whereas the antecedent noun phrase refers to the actual individual herself.

(42) Kate saw *herself* in the mirror.

Rákosi (2009) argues that the Hungarian complex anaphor *önmaga* is especially well-suited to contexts of such referential shifts. In fact, it may even take restrictive adjectival or participial modifiers, as in (43) below.

(43) Hungarian

a	tükör-ben	lát-ott	*önmagam*
the	mirror-in	see-PTCP	myself

'my self/image seen in the mirror'

(43) evokes a context where the speaker feels alienated from his or her own image. To what extent this variation in anaphora interpretation is integral to the study of the grammar of anaphora is partly a matter of perspective (see also Jackendoff 1992 on this issue in general). In any case, if it is, semantic structure is a natural locus to address this issue.

The statement of semantic identity between anaphor and antecedent, in and of itself, does not account for the semantic differences between plural reflexives and reciprocal anaphors, which obviously differ in interpretation. Moreover, reciprocal interpretation is subject to variation from relatively strong (44a) to relatively weak (44b) readings.

(44) a. The students like *each other*.

b. The students followed *each other* into the classroom.

These issues and the overall semantics of reciprocals are discussed at length in Dalrymple et al. (1998) and Haug & Dalrymple (2020). Dalrymple et al. (2018) develop an LFG-based, fine-grained and comprehensive semantic structure representation of anaphoric dependencies within a dynamic semantics framework, which provides a solution to the issues that we have briefly addressed here (see also Dalrymple et al. 2019). What must be stated on the syntactic side, that is, at the level of f-structure, is the requirement that anaphors and antecedents must have matching agreement features. This is achieved in LFG via the INDEX feature set, discussed in detail in Haug forthcoming [this volume].[20]

6 Summary

We have seen that LFG differs from other generative frameworks in explicitly recognizing the empirical fact that anaphoric elements are subject to substantial variation both within and across languages, and no single rule or principle of grammar can capture this versatility in itself. Binding relations are complex dependencies with several parameters, all of which can be stated in the lexical entry of anaphors, in line with the lexicalist nature of LFG grammars.

Research within the LFG tradition also addressed other aspects of the grammar of anaphora which we have not focused on. Constraints on coreference relations including pronouns are discussed in Bresnan et al. (2016), whereas Dalrymple et al. (2018) and Dalrymple et al. (2019) provide an in-depth introduction to the semantic composition of anaphora, including discourse anaphoric relations encoded by personal pronouns and other types of pronominals which we have not touched upon in this chapter.

As happens in other frameworks, too, LFG research has focused mostly on the grammar of reflexive anaphors, but reciprocals have also received attention, see especially Hurst (2006, 2010, 2012) and Hurst & Nordlinger (2021). Morphosyntactic variation is in general significant among different types of anaphors, which, given the f-structure centered approach of LFG, is often not the primary focus of investigation. Nevertheless, a number of LFG works address this variation, from the syntactically active bound anaphoric morphemes in Bantu languages (see Bodomo & Che forthcoming [this volume]) to the monomorphemic markers of

[20] Rákosi (2022) argues on the basis of Hungarian data that at least certain types of anaphors may only constrain the INDEX features of their antecedents, but they do not have INDEX features of their own.

Germanic, Romance and Slavic languages, which may either act as anaphors or as intransitivizers (see, among others, Sells et al. 1987, Alencar & Kelling 2005, Alsina forthcoming [this volume], and Hristov forthcoming [this volume]). Complex reflexives may have even more complex variants, with interesting syntactic and semantic consequences discussed in Rákosi (2009). Bresnan et al. (2016) gives an overview of some issues in typological variation in the morphology of anaphors and its syntactic correlates.

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Abbreviations

Besides the abbreviations from the Leipzig Glossing Conventions, this chapter uses the following abbreviations.

ASP	aspectual marker
CL	classifier

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Chapter 2

Case

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This chapter surveys work on case within LFG, beginning with some of the earliest studies in Bresnan (1982). The chapter then moves on to cover the interaction of Mapping Theory with case marking, Optimality Theoretic approaches to case and the ideas articulated by Constructive Case. It closes with an outlook on more recent analyses. While these recent analyses are couched within current LFG and are applicable to a wider range of phenomena, they echo the basic insights of some of the earliest approaches to case in that they essentially take a lexical semantic view of case, but go beyond the lexicon and use LFG's projection architecture to chart the complex interaction between lexical, structural and semantic/pragmatic factors exhibited by case markers crosslinguistically, including core case markers. Examples in this chapter are drawn mainly from Australian, Scandinavian, and South Asian languages.

1 Introduction

In LFG there is no one theory of case and so this chapter goes through a variety of approaches. While the approaches differ formally and focus on a diverse set of phenomena, they are unified by the same underlying sense of how case should be analyzed. Case marking is seen as being closely connected to the identification of grammatical relations (henceforth grammatical functions or GFs), but also to the realization of lexical semantic information, such as experiencer or causer/causee semantics, instruments, goals, locations, etc. Like any piece of morphological or syntactic information, case is seen as contributing to the overall morphosyntactic and semantic analysis of a clause. That is, case marking is taken to provide important information about GF status (e.g., SUBJ vs. OBJ vs. OBJ_θ or OBL_θ) and about the lexical semantics of the arguments of a predicate. This can go so far as

Miriam Butt. Forthcoming. Case. In Mary Dalrymple (ed.), *Handbook of Lexical Functional Grammar*. Berlin: Language Science Press.

taking the form of 'Constructive Case' whereby the case marking is responsible for the 'creation' or introduction of a particular GF into the syntax (Section 4). For example, the ergative might come with the information that a SUBJ must exist in the clause and thus contribute a SUBJ feature to the f-structure analysis.

The chapter begins with a look at the earliest treatments of case in LFG in Section 2, which developed the basic insights informing later work. Case marking is modeled as a combination of syntactic and lexical semantic information and plays a role in the mapping from semantic arguments to GFs. This is discussed in Section 3, with Section 6 laying out the effects of case at the clausal semantic level, i.e. in terms of telicity or partitivity and modality. Case also appears to have pragmatic impact in that it can express information structural meaning and can be governed by information structural concerns.

With the rise of Optimality Theory (Prince & Smolensky 1993), influential work by Aissen as well as Woolford sought to account for Differential Case Marking (DCM) and other distributions of case via an Optimality Theory (OT) approach (Aissen 1999, 2003, Woolford 2001). LFG took an early interest in the possibilities of OT (Bresnan 2000) and as discussed in Section 5, this included experimenting with OT for analyses of case.

Some of the material in this chapter has already been presented in Butt (2006) and Butt (2008), particularly the description of Constructive Case and the mapping between semantic arguments and GFs. However, this contribution provides a deeper look at case in early LFG and at case within approaches inspired by OT. It also updates the discussion with respect to new proposals for mapping/linking and ties the various facets of case marking together in a sketch for an overall comprehensive approach in Section 7. Section 8 summarizes.

2 Early LFG

Some of the earliest LFG work included papers that were specifically devoted to case. This section discusses the contributions by Neidle (1982), Andrews (1982) and Mohanan (1982) on a diverse range of languages, namely Russian, Icelandic and Malayalam, respectively.

2.1 Russian

Neidle (1982) looked at patterns of case agreement in Russian complements and secondary predicates. In essence, Neidle's overall approach to case did not differ much from what would have been standard assumptions at the time in that

Neidle divides case into two broad categories: 1) *structurally predictable* case; 2) *lexically required* case and exceptions. This bipartite distinction still underlies most of the assumptions and theorizing on case in standard GB/Minimalist approaches, e.g., see Butt (2006), Bobaljik & Wurmbrand (2008) for overviews, and is currently framed as an opposition between dependent vs. inherent case, e.g., Baker & Bobaljik (2017).

A special feature of Neidle's approach is the adoption of Jakobson's feature decompositional approach to case (Jakobson 1936). Neidle also briefly touches on the issue of genitive objects in Russian, which are introduced structurally in the presence of negation and more generally when the object is non-quantized. In the latter case, the genitive may be part of a Differential Case Marking (DCM) pattern by which the genitive is used for non-quantized objects and the accusative for quantized objects, e.g., in verbs such as 'demand' (Neidle 1982: 400). Genitive case is sometimes also required by the inherent lexical semantics of the verb (e.g., 'wish').

Neidle does not quite integrate the quantizedness semantics into her account and instead opts for a simple distinction between structural and inherent case. Structural case is assigned via f(unctional)-structure annotations on c(onstituent)-structure rules, for example the annotations on an object OBJ and an indirect object (termed OBJ2 in early LFG) might look as in (1), where the Jakobsonian-inspired featural decomposition (−, −, +) corresponds to accusative and the (+, −, +) corresponds to a dative.

(1)
$$\text{VP} \longrightarrow \begin{array}{ccc} \text{V} & \text{NP} & \text{NP} \\ \uparrow=\downarrow & (\uparrow \textsc{obj})=\downarrow & (\uparrow \textsc{obj2})=\downarrow \\ & (\downarrow \textsc{case})=(-,-,+) & (\downarrow \textsc{case})=(+,-,+) \end{array}$$

The structural case assignment is matched up with the functional information gleaned from the morphological case marking on nouns, pronouns, adjectives, etc. That is, if a phrase structure rule as in (1) calls for an accusative object, then whatever noun or pronoun this NP is instantiated by needs to have accusative morphology. Given this approach to structural case, the lexical entries for verbs generally contain no information about case: as shown in (2), verbs specify the type and number of the GFs that are expected (as per basic LFG theory), but do not contain additional information about case.[1]

(2) %vstem V (↑ PRED)='%vstem⟨(↑ SUBJ),(↑ OBJ)⟩'

[1]The lexical entry in (2) has been adapted from the original with respect to how a verb stem is represented. The % indicates a variable that can be filled by some value (Crouch et al. 2011). In the lexical entry in (2), this might be the verb 'kill', for example.

On the other hand, a specification for case marking is added to those verbal entries where the case marking patterns are identifiable as being due to the semantics of the verbs (e.g., 'wish'). This is illustrated in (3), where the case information corresponds to a genitive.[2]

(3) *wish* V (↑ PRED)='WISH⟨(↑ SUBJ),(↑ OBJ)⟩'
(↑ OBJ CASE) = (−, +, +)

Effects of the genitive of negation are handled at the c-structural level, with the rule introducing the negation also introducing information that triggers genitive case on the object. The overall approach is thus one in which there is a complex interaction between c-structural, morphological and lexical information. While Neidle's particular approach in terms of the Jakobsonian inspired featural decomposition of case was not taken up in LFG, the basic approach to modeling the interplay between lexical semantics, phrase structure and morphological information continues to inform LFG.

2.2 Icelandic

As exemplified by Neidle's approach, there has never been an assumption within LFG that case should be associated strictly with one GF (or vice versa) or that agreement and case should be inextricably bound up with one another. This is because of the very early recognition within LFG that in addition to non-accusative objects such as those found in Russian: 1) non-nominative subjects also exist in the world's languages and thus need to be accounted for; 2) agreement does not necessarily track subject status. This was famously established in the early days of LFG with respect to Icelandic (Andrews 1976, Zaenen et al. 1985). In both of the examples in (4) (based on Andrews 1982: 462–463) the dative argument can be shown to be a subject via a battery of subject tests such as reflexivization, control, subject-verb inversion, extraction from complement clauses and subject

[2]The explanation of Neidle's approach here is designed to provide the essence of her ideas, not the particulars. As such the lexical entry is simplified and as part of this simplification, the verb stem has been given in English. The overall analysis Neidle proposes for Russian is complex in its details and the interested reader is referred to the original paper both for more information as to the feature decomposition approach to case and the details of the complex interaction between morphology, c-structure and the lexicon that she maps out. However, as Neidle's paper is one of the earliest papers on LFG and the theory has developed since, particularly with respect to approaches to morphology, attempting to provide more details as to her approach as part of this chapter (as some reviewers have suggested) would lead us too far afield into a comparison of early vs. current LFG.

ellipsis. The example in (4b) additionally shows that agreement is not an indicator of subjecthood in Icelandic since the third singular verb does not agree with the first person singular subject.

(4) Icelandic

a. Barn-inu batnaði veik-in.
child-DEF.DAT recovered.from.3SG disease-DEF.NOM
'The child recovered from the disease.'

b. Mér er kalt.
I.DAT be.3SG cold
'I am cold.'

Andrews (1982) also discusses instances of non-accusative objects[3] and notes that nominative objects are the rule in dative subject examples as in (4a). These and other considerations lead Andrews to provide a rich and detailed analysis of the case marking patterns in Icelandic as part of a longer paper on Icelandic syntax.

The overall approach to case is similar to that taken by Neidle, though the formalization is quite different. Like Neidle, Andrews (1982) invokes Jakobson on case, but does not adopt a feature decomposition approach. Rather, he builds on Jakobson's idea that the nominative should be analyzed as a default, unmarked (almost non-case) in Indo-European. As a consequence, Andrews develops an account by which nominative is assigned as a default case as part of the syntax (c-structure rules) if no other case has been specified. Accusative is assigned to objects as a default as well, but only in a structure where there is a nominative subject. All other case marking is specified as part of the lexicon.

Andrews specifically notes that the choice of non-default case marking is not arbitrary, but can be tied to semantic generalizations such as experiencer/perception semantics, the semantics of verbs of lacking and wanting, etc. (Andrews 1982: 463). Essentially, non-nominative subjects all seem to mark non-agentivity of one sort or another. However, despite a sense of systematicity underlying the connection between semantics and case marking, Andrews decides that because there is no invariant meaning one can assign to a case, a strategy of encoding non-nominative subject (and non-accusative object) case as part of the lexicon should be followed: "case selection is basically lexical and idiosyncratic, but subject to regularities keyed to the semantics of the matrix verb" (Andrews 1982: 464). As in Neidle's approach, further structurally motivated instances of non-default case marking are allowed. This is exemplified by structural genitives in

[3]Also see Svenonius (2002) for a more recent in-depth analysis of non-accusative object marking.

Russian, and in Icelandic non-default case occurs in some instances of passivization. Other case marking that goes beyond the core patterns is dealt with via lexically (or otherwise) stipulated information.

Interestingly, Andrews' basic approach foreshadows the notion of *Dependent Case* (Marantz 2000, Baker 2015). This sees the central problem of case theory as deciding on how to apportion structural case between two core argument participants, with the case marking of one being dependent on the structure of the other. So, if a subject is ergative, there are mechanisms in place which ensure that the object is nominative/absolutive. This is similar (but not identical) to Andrews' treatment of nominative objects in the presence of dative subjects and accusative objects in the presence of nominative subjects.

2.3 Malayalam

A different approach to case is taken by Mohanan (1982). Working on Malayalam, Mohanan entertains an approach pioneered by the Sanskrit grammarian Pāṇini (Böhtlingk 1839–40) and taken up by Ostler (1979). This holds that the distribution of case can be expressed in terms of generalizations referring directly to thematic/semantic roles. However, Mohanan shows that it is also necessary to assume a structural level at which GFs are encoded in order to be able to properly account for the distribution of case in Malayalam. That is, the level of GFs (f-structure) must mediate between the overt expression of case and the lexical semantics of verbs. In line with Andrews' findings for Icelandic, Mohanan establishes a systematic relationship between lexical semantics and case, but not a one-to-one relationship. In a precursor to Mapping Theory (section 3), Mohanan proposes the principles in (5).[4]

(5) **Principles of Case Interpretation**

a. Intrepret accusative case as the direct object (OBJ).

b. Interpret dative case as either the indirect object (OBJ2) or the subject (SUBJ).

c. Interpret nominative case as either the subject (SUBJ) or the direct object (OBJ) if the NP is [−animate]; otherwise interpret nominative case as the subject (SUBJ).

There are several things to note about these principles. For one, they assume that case marking plays a central role in the determination of GFs (rather than

[4]These have been simplified slightly with respect to the dative for ease of exposition.

constituting features that must be spelled out, checked off or interpreted, as in GB/Minimalist approaches, for instance). For another, the animacy condition in (5c) constitutes an indirect analysis of the DCM phenomenon found in Malayalam whereby animate objects must be marked with the accusative.

The Principles of Case Interpretation are encoded in the grammar via f-structural annotations on c-structure rules which ensure that indirect objects are dative, subjects are either nominative or dative and objects either accusative or nominative. Mohanan is able to capture this space of possibilities elegantly by also working with Jakobson's case features. While the alternation between nominative and accusative objects is taken to be governed by animacy (via wellformedness checking at f-structure), no general principles for the appearance of dative vs. nominative subjects are built into the system. Rather, like Neidle and Andrews, Mohanan steers the licensing of dative subjects via lexical stipulation in the verb's entry, as shown in (6), taken from Mohanan (1982: 545). He classifies both 'sleep' and 'be hungry' as intransitive experiencer verbs. The nominative case on the subject of the verb 'sleep' is taken to follow from the general Principles of Case Interpretation in conjunction with the functional annotations on the c-structure rules. On the other hand, the verb 'be hungry' is lexically stipulated to have a dative subject. The choice of dative vs. nominative subjects is thus steered via the presence or absence of information found in the lexical entries.

(6) a. *uraŋŋ* V (↑ PRED)='SLEEP⟨ $\underset{\text{EXPERIENCER}}{(\uparrow \text{SUBJ})}$ ⟩'

b. *wiśakk* V (↑ PRED)='BE HUNGRY⟨ $\underset{\text{EXPERIENCER}}{(\uparrow \text{SUBJ})}$ ⟩

Mohanan generally assumes that a verb's lexical entry expresses both the thematic roles it takes and the grammatical relations that these correspond to, as shown in (6) and (7). This is in line with early LFG approaches to predicate-argument structure, which assumed a close connection between thematic roles and GFs but did not yet articulate that relationship in any detail (cf. the contributions in Butt & King (2006 [1983])). The articulation of this relationship came with the advent of linking (Section 3).

(7) *ṯinn* V (↑ PRED)='EAT⟨$\underset{\text{AGENT}}{(\uparrow \text{SUBJ})}$, $\underset{\text{PATIENT}}{(\uparrow \text{OBJ})}$ ⟩'

LFG's work on the linking or *mapping* between thematic roles and GFs in the 1980s and 1990s also entailed a closer look at the lexical semantics of verbs and verb classes, with detailed work such as that by Jackendoff (1990) and Levin (1993) providing inspiration. As such, the conclusions arrrived at by Mohanan that the case patterns in Malayalam are too irregular to be governed by general principles deserve a second look from today's perspective. Consider, for example, the contrasts in (8) and (9), taken from Mohanan (1982: 540–541).[5] Mohanan considers the verbs to "…presumably have the same thematic roles" (Mohanan 1982: 540), namely to all have experiencer arguments. However, the 'became' in (8a) is rather more indicative of an undergoer/patient so this is more likely to be an unaccusative, rather than an experiencer verb. This difference in lexical semantics is likely to govern the difference in subject case so that experiencer semantics is expressed via a dative subject while unaccusatives simply receive a nominative subject by default.

(8) Malayalam

a. awaḷ taḷarn̲n̲u.
   she.NOM was tired
   'She became tired.'

b. awaḷ-kkə wiš̄an̲n̲u.
   she-DAT hungered
   'She was hungry.'

Similarly, the contrast between (9a) and (9b) can potentially be explained by (9b) involving a metaphorical location ('happiness came to me'), which lends itself to dative subjects, as argued for by a.o. Landau (2010) and suggested by Localist approaches to case and argument structure, e.g. Gruber (1965), Jackendoff (1990).

(9) Malayalam

a. ñaan san̲t̲ooṣiccu.
   I.NOM was happy
   'I was happy.'

b. eni-kkə san̲t̲ooṣam wan̲n̲u.
   I-DAT happiness came
   'I was happy.'

Contrasts such as in (9) are standardly and systematically found in South Asian languages and they thus deserve a better explanation than being relegated to

[5] The glosses in these Malayalam examples provide slightly more detail than in the original.

lexical stipulation. The same applies to contrasts as in (10), from Mohanan (1982: 542), where a difference in modality is expressed solely in terms of a difference in case marking on the subject.

(10) Malayalam
  a. kuṭṭi aanaye ṇuḷḷ-aṇam.
  child.NOM elephant.ACC pinch-MOD
  'The child must pinch the elephant.'
  b. kuṭṭi-kkə aanaye ṇuḷḷ-aṇam.
  child-DAT elephant.ACC pinch-MOD
  'The child wants to pinch the elephant.'

Mohanan again resorts to lexical stipulation to model the two different readings (permission vs. promise), but given that these types of contrasts are also widely found in other South Asian languages (Butt & Ahmed Khan 2011, Bhatt et al. 2011), again a more principled analysis is in order (see Section 7).

3 Mapping Theory

Over time, the understanding of case and its relationship with predicate arguments deepened and LFG developed a dedicated *Mapping Theory* to model and explain the systematicity found across a typologically diverse set of languages. A subset of the semantics associated with case have thus by now been covered by this more principled account of the relationship between lexical semantics and GFs. This section briefly charts the development of Mapping Theory from early ideas and formulations to today's standard instantiation, focusing particularly on the role of case. The reader is referred to Findlay & Kibort forthcoming [this volume] for a fuller discussion of Mapping Theory and more recent developments.

3.1 Association Principles with Case

It is perhaps no accident that the beginnings of LFG's Mapping Theory were first articulated with respect to Icelandic (Zaenen et al. 1985) — a language with robust case marking that attracted intense linguistic interest in the 1980s because of its demonstrated use of non-nominative subjects (Andrews 1976). Zaenen et al. (1985) present a detailed study of the interaction between Icelandic case and GFs, which bears similarities to the approaches sketched in the previous section. However, the Icelandic Association Principles formulated by Zaenen et al. (1985) in

(11) contrast with Mohanan's principles for Malayalam. Where Mohanan linked case directly to GFs, Zaenen et al. (1985) postulate a complex interrelationship between case, thematic roles and GFs. Another feature of the principles is that they include universal as well as language specific postulations, as can be seen via a comparison of Icelandic and German, for which Zaenen et al. (1985) provide a comparative analysis.

(11) **Icelandic Association Principles**

1. AGENTS are linked to SUBJ (Universal)
2. Casemarked THEMES are assigned to the lowest available GF. (Language Specific)
3. If there is only one thematic role, it is assigned to SUBJ; if there are two, they are assigned to SUBJ and OBJ; if there are three, they are assigned to SUBJ, OBJ, 2OBJ.[6] This principle applies after principle 2 and after the assignment of restricted GFs. (Universal)
4. Default Case-Marking: the highest available GF is assigned NOM case, the next highest ACC. (Universal)

(12) **German Association Principles**

1. AGENTS are linked to SUBJ (Universal)
2. Casemarked THEMATIC ROLES are assigned to 2OBJ. (Language Specific)
3. If there is only one thematic role, it is assigned to SUBJ; if there are two, they are assigned to SUBJ and OBJ; if there are three, they are assigned to SUBJ, OBJ, 2OBJ. This principle applies after principle 2 and after the assignment of restricted GFs. (Universal)
4. Default Case-Marking: the highest available GF is assigned NOM case, the next highest ACC. (Universal)

Like the 1982 approaches of Neidle, Mohanan and Andrews, Zaenen et al. (1985) rely on a mix of universal and structurally determined case assignment (default nominative on subjects and accusative on objects), language specific rules and lexically stipulated case marking patterns. However, Zaenen et al. (1985) differ significantly from Andrews' approach to Icelandic in that they include thematic roles in the statement of generalizations and associate case as one of several features with a given GF. Andrews, on the other hand, argued for the use of a "composite function" in which GF and case information are welded together to provide

[6]This corresponds to OBJ_θ within later LFG approaches

differentiation among GFs. So for example, one could have a SUBJ DAT vs. a SUBJ ACC or OBJ ACC. These composite functions were licensed by a complex interplay between f-structure annotations and lexical specifications. Over time, Zaenen et al.'s technically simpler but architecturally more complex approach was adopted as the standard way of thinking about Icelandic case marking patterns within LFG.

3.2 Argument Structure

We here illustrate Zaenen et al.'s system by way of the example in (13) (Zaenen et al. 1985: 470). The Icelandic verb *óska* 'to wish' is ditransitive, but the goal argument ('her' in (13)) is optional.

(13) Icelandic

þú	hefur	óskað	(henni)	þess
you	have	wished	her.DAT	this.GEN

'You have wished this on/for her.'

The genitive and dative on the theme and goal arguments, respectively, are encoded as part of the lexical entry of the verb, as shown in (14). Note that this lexical entry differs from those encountered in the 1982 papers in that Zaenen et al. (1985: 465) "postulate a level of representation at which the valency of a verb is determined and its arguments can be distinguished in terms of thematic roles." The encoding of the number and type of arguments of a verb via a separate level of argument structure was due to a forceful demonstration by Rappaport (1983) with respect to derived nominals that argument structure needed to be posited as an independent level of representation.[7]

(14)

óska:	< agent	theme	(goal)>
		[+gen]	[+dat]
a.	SUBJ	2OBJ	OBJ
b.	SUBJ	OBJ	
	[+nom]		

The thematic roles in the verb's argument structure are linked to GFs via the Association Principles in (11). The agent is linked to SUBJ and receives nominative case via the universal principles in 1 and 4. When the goal argument is present,

[7] See Chomsky (1970) for similar conclusions with respect to nominalizations, which led to a general understanding of argument structure as a separate level of representation, currently often realized as vP in Minimalist approaches to syntax.

the case marked theme is assigned to the lowest available GF (Principle 2, language specific), which is the secondary object. That leaves the goal argument to be assigned to the OBJ, since by Principle 3 (universal) if there are three thematic roles, they need to be assigned to SUBJ, OBJ and 2OBJ. In this case SUBJ and 2OBJ have already been assigned, leaving only OBJ.

When the goal argument is not present, the agent is again linked to SUBJ and receives nominative case via the universal principles in 1 and 4. But this time the genitive case marked theme is assigned to OBJ as the lowest available GF, as shown in (14b). The status of OBJ is significant as it is this argument that can be realized as a subject under passivization. The lexically determined case marking is also significant, as these cases tend to be retained in constructions like the passive, as shown in (15) (Zaenen et al. 1985: 471).

(15) Icelandic

a. þess var óskað (*henni)
this.GEN was wished her.DAT
'This was wished.'

b. Henni var óskað þess
her.DAT was wished this.GEN
'She was wished this.'

Today's standard Mapping Theory relates GFs to thematic roles via two abstract linking features, [±O](bjective) and [±R](estrictive), by which both thematic roles and GFs can be classified (Bresnan & Zaenen 1990, Bresnan 2001, Butt 2006). Additionally, a number of principles govern the association of GFs and thematic roles. These principles were worked out on the basis of a wide range of data, including Bantu, Germanic and Romance. LFG's Mapping Theory can account for a wide range of argument changing operations such as locative inversion, causativization, passives (argument deletion) or applicatives (argument addition), e.g. see Levin (1987), Alsina & Mchombo (1993), Bresnan & Kanerva (1989), Bresnan & Moshi (1990), Alsina & Joshi (1991).

Based on his work with Romance languages (mainly Catalan), Alsina (1996) proposed an alternative version of Mapping Theory and in recent years, Kibort has worked out a revised version, which abstracts away from the use of thematic roles, instead working with abstract argument positions and a complex interplay between syntax and semantics (Kibort 2007, 2013, 2014, Kibort & Maling 2015). This chapter does not delve further into the details of linking as the role of case in most versions of linking has stayed much as it was in Zaenen et al.'s analysis of Icelandic: an extra piece of information that helps determine the mapping between GFs and thematic roles and that needs to be accounted for as part of the mapping between argument structure and GFs. See Butt (2006) and Findlay & Kibort forthcoming [this volume] for overview discussions.

However, we will include a discussion of Schätzle (2018) in Section 6, as she works with Kibort's revised version of linking, and develops an event-based theory of linking for an analysis of the historical rise and spread of dative subjects in Icelandic (yes — again Icelandic!).

3.3 Quirky Case

Before moving away from the early LFG approaches to case and linking, this section takes a look at a significant concept that also resulted from the concentrated work on Icelandic: *lexically inherent* or *quirky case*. The data from Icelandic and other languages support a distinction between at least two types of case assignment/licensing. In the papers discussed so far, this was thought of as a distinction between structurally assigned and "lexically inherent" case. The latter also came to be known as "quirky case".

However, the anchoring of case marking information in lexical entries together with the term "quirky" suggests a random lawlessness that must be idiosyncractically stipulated as part of lexical entries. This view on non-default case has become widely accepted within linguistics, but lacks empirical support. As already noted by Andrews (1982) for Icelandic, for example, and confirmed by the data and analyses in Zaenen et al.'s paper, the correlation between thematic role and case marking in Icelandic is actually quite regular in that the "quirky" cases are generally regularly associated with a given thematic role. There seem to be only very few instances of truly idiosyncratic case marking that do not follow from general semantic principles.

Van Valin (1991) explicitly revisited the Zaenen et al. paper and made this point, working out an alternative analysis within Role and Reference Grammar (RRG). Van Valin (1991) takes an event-based approach, working with differences between Vendlerian states, activities, achievements and accomplishments in combination with a macro-role approach to the arguments of a predicate. The paper mainly focuses on dative arguments, whereby dative case is assigned to those arguments which cannot be assigned a macro-role (either actor or undergoer). Dative arguments thus constitute the 'elsewhere' case and do not need to be lexically encoded/stipulated. Van Valin does not explicitly address the other types of non-default case marking.

Although Van Valin frees dative marked arguments from being lexically stipulated, he also essentially works with a bipartite system: case marking which is determined systematically via reference to macro roles vs. case marking that is idiosyncratic. However, the empirical evidence supports a tripartite, rather than a bipartite approach to case: 1) structural case (e.g., nominative/accusative), 2) semantically conditioned case; 3) idiosyncratic case. Despite the empirical evidence for a tripartite view, this approach constitutes an exception rather than the rule in the literature. Versions of a tripartite view of case marking have been argued for by Donohue (2004) and Woolford (2006), for example. Within LFG this view was first clearly articulated by Butt & King (2004), see Section 7.

4 Constructive Case

In this section we turn to a very different type of case marking, namely a phenomenon that has come to be known as *case stacking*, illustrated in (16). Within LFG, Nordlinger (1998, 2000) took on this phenomenon with respect to Australian languages and proposed a strongly lexicalist analysis in which the case markers themselves contribute information about the GFs of a clause.

(16) Martuthunira (Dench 1995: 60)

Ngayu	nhawu-lha	ngurnu	tharnta-a	mirtily-marta-a
I.NOM	saw-PST	that.ACC	euro-ACC	joey-PROP-ACC

thara-ngka-marta-a.
pouch-LOC-PROP-ACC

'I saw the euro with a joey in (its) pouch.'

In (16) the main predicate is 'see', which takes a nominative subject ('I') and an accusative object, 'euro' (a type of kangaroo). The clause also contains two modifying NPs, 'joey' (a baby kangaroo) and 'pouch'. The accusative on these nouns signifies that they modify the OBJ 'euro', the proprietive shows that these are part of a possessive or accompanying relation to another word and the locative on 'pouch' signals that this is the location of the joey. The f-structure in (17) shows these dependency relations among the NPs.

(17)
$$
\begin{bmatrix}
\text{PRED} & \text{`SEE}\langle\text{SUBJ,OBJ}\rangle\text{'} \\
\text{SUBJ} & \begin{bmatrix} \text{PRED} & \text{`PRO'} \\ \text{NUM} & \text{SG} \\ \text{PERS} & 1 \\ \text{CASE} & \text{NOM} \end{bmatrix} \\
\text{OBJ} & \begin{bmatrix} \text{PRED} & \text{`EURO'} \\ \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{CASE} & \text{ACC} \\ \text{ADJUNCT} & \left\{ \begin{bmatrix} \text{PRED} & \text{`JOEY'} \\ \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{CASE} & \text{PROP} \\ \text{ADJUNCT} & \left\{ \begin{bmatrix} \text{PRED} & \text{`POUCH'} \\ \text{PERS} & 3 \\ \text{NUM} & \text{SG} \\ \text{CASE} & \text{LOC} \end{bmatrix} \right\} \end{bmatrix} \right\} \end{bmatrix} \\
\text{TENSE} & \text{PST} \\
\text{MOOD} & \text{INDICATIVE}
\end{bmatrix}
$$

None of this case marking by itself is out of the ordinary, what is special is the ability of languages like Martuthunira to stack cases on top of one another. In a language like Martuthunira that has fairly free word order, this stacked marking of dependents unambiguously indicates which elements belong to which other elements syntactically (see Butt (2000) for some discussion).

The individual case markers could be dealt with straightforwardly by a mix of structural and lexically inherent case, as had been done in the past. However, the case stacking is a different matter. It is not particularly feasible to stipulate all possible case stacking patterns in the lexical entries of the verbs. This kind of "anticipatory" case marking would lead to an unwanted proliferation of disjunctions in the verbal lexicon. Given that Martuthunira has fairly free word order, trying to write rules in the syntax that would anticipate all possible patterns of case stacking would result in an unwieldy and uninsightful treatment of the phenomenon.

Instead, Nordlinger's solution is to see case morphology as being *constructive* in the sense that a case marker comes with information as to what type of GF it is expecting to mark. Formally, this is accomplished via *inside-out functional designation* (Dalrymple 1993, 2001), as illustrated in the (sub)lexical entries for the case markers in (18). The first line in each of the entries is standard: each case marker specifies that the attribute CASE is assigned a certain value (ergative, accusative, etc.). This ensures that whatever constituent carries the case marker will be analyzed as ergative, or accusative, or locative, etc.

The second line in each entry has the ↑ behind the GF rather than in front of it, signaling inside-out functional designation (Belyaev forthcoming: ?? [this volume]). This has the effect of adding a constraint on the type of GF the case marker can be associated with. In (18) the effect is that the ergative is constrained to appear within a SUBJ, the accusative within an OBJ, etc.[8]

(18)
a. ERGATIVE: (↑ CASE) = ERG
(SUBJ ↑)

b. ACCUSATIVE: (↑ CASE) = ACC
(OBJ ↑)

c. LOCATIVE: (↑ CASE) = LOC
(ADJUNCT ↑)

b. PROPRIETIVE: (↑ CASE) = PROP
(ADJUNCT ↑)

Nordlinger works on the Australian language Wambaya and develops an analysis of the complex interaction between morphology and syntax that characterizes case stacking. Reproducing the entire analysis including an explanation of Wambaya morphosyntax goes far beyond the limited space available in a handbook article: this section therefore stays with the Martuthunira example for purposes of illustrating the general idea behind constructive case.

For the sake of concreteness, this section assumes a view of the morphology-syntax interface in which sublexical items are produced by rules which are analogous to phrase structure rules. This is the approach generally adopted in the ParGram grammar development world (Butt et al. 1999) and as such is useful for a concrete illustration. Note, however, that current LFG literature differs on assumptions as to the morphology-syntax interface. The illustration here adopts the general architecture articulated in Dalrymple (2015).

To begin with, let us consider the partial f-structure resulting from just the information on ‘pouch’ shown in (19). The stacked case marking on this noun

[8] Andrews (1996) also takes on case stacking and also uses LFG’s inside-out functionality. However, his focus is on the interaction between morphology and syntax, rather than on case per se.

not only provides information on the case of the noun (the innermost case morphology), it also "anticipates" the larger structure it will be embedded in. The PREDs of that larger structure will be filled in as part of the overall annotated c-structural analysis, with the partial f-structures corresponding to each of the nouns (and the verb) unifying into the full f-structure in (17).

(19)
$$\left[\text{OBJ}\ \left[\begin{array}{ll}\text{CASE} & \text{ACC}\\ \text{ADJUNCT} & \left\{\left[\begin{array}{ll}\text{CASE} & \text{PROP}\\ \text{ADJUNCT} & \left\{\left[\begin{array}{ll}\text{CASE} & \text{LOC}\\ \text{PRED} & \text{`POUCH'}\\ \text{NUM} & \text{SG}\\ \text{PERS} & 3\end{array}\right]\right\}\end{array}\right]\right\}\end{array}\right]\right]$$

Recall that the inside-out function designation only serves as a constraint on f-structure. That, is the information found on 'pouch' postulates that there should be an OBJ into which it can be embedded. This condition will only be fulfilled if such an OBJ ends up being introduced somewhere so the actual introduction of the OBJ thus needs to come from some other part of the syntax or lexicon.

For purposes of illustration, let us assume a (simplified) phrase structure rule for clauses as in (20), which reflects the tendency in Australian languages for a (finite) verb to be in second position and models the general free word order for Australian languages. We can thus have one GF or an adjunct introduced by the XP before the verb and any GF or adjuncts after the verb. Note that "GFS-ADJ" is a template that is expandable as in (21). Similarly, XPs could be expanded to a number of different phrase structure categories, including NPs.

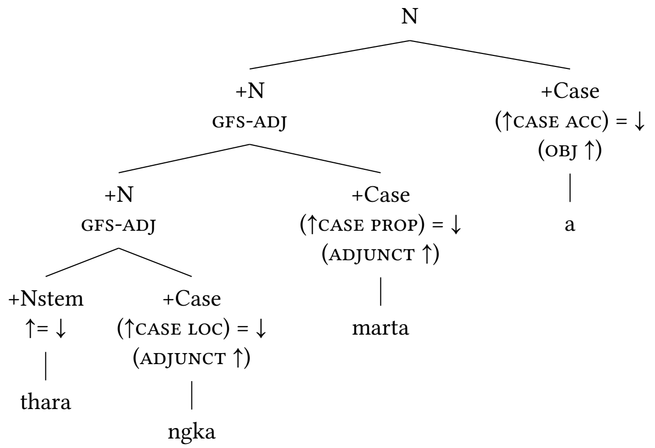
(20)
$$\begin{array}{llccc}\text{S} & \longrightarrow & \text{XP} & \text{V} & \text{XP}^{*}\\ & & @\text{GFS-ADJ} & \uparrow=\downarrow & @\text{GFS-ADJ}\end{array}$$

(21)
$$\begin{array}{l}\text{GF-ADJS} = \{\, (\uparrow \text{SUBJ}) = \downarrow \mid (\uparrow \text{OBJ}) = \downarrow \mid (\uparrow \text{OBL}_{\theta}) = \downarrow\\ \qquad\qquad \mid (\uparrow \text{OBJ}_{\theta}) = \downarrow \mid \downarrow \in (\uparrow \text{ADJUNCT})\}\end{array}$$

Since most of the action takes place in the morphological component in Martuthunira, let us take a look at a possible sublexical structure (for a discussion of sublexical structure and sublexical rules, see Belyaev forthcoming: ?? [this volume]. In (22) the N expands into a set of sublexical categories, marked with a + for ease of exposition. In our example, we have a noun stem that can combine with a case marker, yielding a sublexical N (+N). This can combine with further case markers, as shown in (22), finally yielding an N.[9]

[9] Of course, the possible space of combinations in the morphological component must be constrained and this can be done quite simply by writing suitable sublexical rules, but describing all the details here would take us too far afield.

(22)



The inside-out functional designation on *ngka*, for example, requires that this be part of an adjunct. This is only a constraint and as such does not "construct" the adjunct per se. However, taken together with the space of possibilties licensed by the functional annotations on the mother +N node, the inside-out designation has the effect of selecting exactly the adjunct among the space of possibilities provided by the expansion of gfs-adj in (21) and thus, in effect, serving to "construct" this gf by way of the sublexical specification on the case marker.

The same formal effect is found with the accusative marker — here the governing gf is constrained to be an obj and this causes the obj option to be selected from the set of possibilities in (21), but this time they are selected from the functional annotations on the xp in rule (20), which is instantiated by an np and expands into the N in (22).

Overall, taking together the functional annotations in the phrase structural and the sublexical space within the N leads us to the f-structure in (19). This partial f-structure can then be unified straightforwardly with information coming from other parts of the clause via the standard unification mechanism in LFG. For example, the unification of (19) with the partial f-structure corresponding to the word *mirtily-marta-a* 'joey-prop-acc' shown in (23) results in the unified f-structure in (24). This unification takes place with respect to the information coming from the other words in the clause as well, resulting in the final f-structural analysis in (17).

(23)
$$\left[\begin{array}{ll} \textsc{obj} & \left[\begin{array}{ll} \textsc{case} & \textsc{acc} \\ \textsc{adjunct} & \left\{\left[\begin{array}{ll} \textsc{case} & \textsc{prop} \\ \textsc{pred} & \text{`}\textsc{joey}\text{'} \\ \textsc{num} & \textsc{sg} \\ \textsc{pers} & 3 \end{array}\right]\right\} \end{array}\right] \end{array}\right]$$

(24)
$$\left[\begin{array}{ll} \textsc{obj} & \left[\begin{array}{ll} \textsc{case} & \textsc{acc} \\ \textsc{adjunct} & \left\{\left[\begin{array}{ll} \textsc{case} & \textsc{prop} \\ \textsc{pred} & \text{`}\textsc{joey}\text{'} \\ \textsc{num} & \textsc{sg} \\ \textsc{pers} & 3 \\ \textsc{adjunct} & \left\{\left[\begin{array}{ll} \textsc{case} & \textsc{loc} \\ \textsc{pred} & \text{`}\textsc{pouch}\text{'} \\ \textsc{num} & \textsc{sg} \\ \textsc{pers} & 3 \end{array}\right]\right\} \end{array}\right]\right\} \end{array}\right] \end{array}\right]$$

Nordlinger's constructive case idea thus establishes case marking as carrying important information for the overall clausal analysis and invests case markers with (sub)lexically contributed information. Because the GF specifications on the case markers clearly signal which parts of the clause belong together, effects of free word order are accounted for automatically. For example, the discontinuous constituents, as illustrated in the Wambaya example in (25), can be treated very naturally. As sketched above for Martuthunira, each word in the clause produces a partial f-structure. These partial f-structures are then unified with others to produce the overall analysis, with the particular position in the clause or adjacency not mattering for the f-structural analysis. What matters is the compatibility of the information coming from the various bits and pieces of the clause, which means that discontinunous constituents which are each marked as ergative will end up being unifed under the same GF at f-structure, in this case the ergative subject.

(25) Wambaya (Nordlinger 1998: 96)

galalarrinyi-ni	gini-ng-a	dawu	bugayini-ni
dog.I-ERG	3SG.M.A-1.O-NFUT	bite	big.I-ERG

'The big dog bit me.'

Butt & King (1991, 2004) take a similarly constructive approach to case in addressing the case marking and free word order patterns of Urdu and they combine this with a theory of linking. This is discussed in Section 7. Before moving on to this and some further aspects governing the distribution of case from an LFG perspective, we however first delve into the insights offered by an adoption of Optimality Theory into LFG.

5 Optimality-Theoretic Approaches

Optimality Theory (OT) was originally formulated with respect to phonological phenomena (Prince & Smolensky 1993, Kager 1999), but quickly found its way into syntactic work (Grimshaw 1997) and analyses of case patterns (Legendre et al. 2000). OT assumes an architecture by which several input candidates are generated by a given grammar. These input candidates are subject to a series of ranked constraints and result in just one of the candidates being picked as the most "optimal", i.e. as the resulting surface string. This version of OT is essentially focused on production, but a *bidirectional* version of OT, which could take both the production and the comprehension perspective into account, has been formulated as well (Blutner 2000, Dekker & von Rooy 2000). Constraints are assumed to be universally applicable across all languages, but the rankings of the constraints may differ, giving rise to language-particular patterns (see Kuhn forthcoming [this volume] for an overview).

Bresnan (2000) introduced a version of OT that is compatible with LFG, arguing for the merits of this approach. Within OT-LFG, the input to an evaluation by OT constraints is assumed to be f-structure and c-structure pairings and the task of the OT constraints is to pick out the most optimal pairing. Work on case within OT-LFG has generally built on Bresnan's blueprint as well as the notions introduced by bidirectional OT.

5.1 Harmonic Alignment and DCM

OT-LFG work on case also made crucial use of the ideas in Aissen's seminal OT papers (Aissen 1999, 2003), in which she proposes a series of typologically motivated "Harmonic Alignment Scales" to account for DCM. For example, Aissen works with Silverstein's famous person and animacy hierarchy with respect to split ergativity (Silverstein 1976). She distills his and other insights found in the literature into three *universal prominence scales* shown in (27). These scales are applied to DCM, for example, with respect to differential subject marking of the type illustrated in (26) for Punjabi. In Punjabi third person subjects, but not first or second person subjects, may be overtly marked with ergative case.

(26) a. mɛ̃ bɑkra vec^{h}-i-a
PRON.1.SG.F/M goat.M.SG.NOM sell-PST-M.SG
'I (male or female) sold the goat.' Punjabi

b. o=ne bɑkra vec^{h}-i-a
PRON.3.SG.F/M=ERG goat.M.SG.NOM sell-PST-M.SG
'He/She sold the goat.' Punjabi

(27) Thematic Role Scale: Agent > Patient
Relational Scale: Subject > Nonsubject
Person Scale: Local Person (1st&2nd) > 3rd Person

The three separate preference scales interact across languages. Within OT this interaction is modeled via the concept of *Harmonic Alignment* (Prince & Smolensky 1993), by which each element of a scale is associated with an element of another scale, going from right to left. The Harmonic Alignment of just the Relational and the Person scale in (27) is shown in the second column in (28) (Aissen 1999: 681). The third column in (28) shows the OT constraints derived from the Harmonic Alignment of the two scales. The constraints are arrrived at by interpreting the ranked elements in the Harmonic Alignment as situations which should be avoided, whereby lower ranked elements are the ones to be avoided more strongly than a higher ranked element. So in column 2 the 'x ≻ y' means 'x is less marked/more harmonic than y', and in column 3 the 'x ≫ y' means that the x constraint is ranked higher, i.e., is stronger, than the y constraint.

(28)

Scales	Harmonic Alignment	Constraint Alignment
Local > 3 Su > Non-Su	Su/Local ≻ Su/3 Non-Su/3 ≻ Non-Su/Local	*Su/3 ≫ *Su/Local *Non-Su/Local ≫ *Non-Su/3

Constraints within OT are understood to interact with a notion of markedness, with constraints conspiring to work towards unmarked situations and against marked situations. The Harmonic Aligment scales above state that 1st and 2nd person subjects are less marked than 3rd person subjects and that 3rd person non-subjects are less marked than 1st or 2nd person non-subjects (as per typological observations). Under the assumption that overt case is used to flag those NPs which are marked in some way, these scales and the constraints derived from them correctly predict that ergative case is more likely to occur on 3rd person subjects (the more marked situation), rather than on 1st person subjects. And this is indeed what is observed in Punjabi (26) and crosslinguistically.

Aissen derives another set of constraints targeting the realization of case on objects, these are provided in (29). She uses these constraints to provide an analysis of well-known Differential Object Marking (DOM) phenomena, such as the definiteness and specificity effects discussed for Turkish by Enç (1991); see also Butt (2006) for an overview discussion.

(29) Relational Scale: Subject > Nonsubject
Animacy Scale: Human > Animate > Inanimate
Definiteness Scale: Pronoun > Proper Name > Definite > Indefinite Specific > Nonspecific

Again, these relational scales are based on crosslinguistic observations. We have already seen animacy playing a role in Malayalam case assignment (Section 2). This feature, along with others, also plays a role in Indo-Aryan case marking, as illustrated via the specificity alternation (see (31) for an example).

5.2 OT-LFG and Case

Working broadly within OT-LFG, Deo & Sharma (2006) take on the interaction between verb agreement and "core" case marking (ergative, accusative and nominative) on subjects and objects in a range of Indo-Aryan languages. The patterns are complex, but Deo and Sharma identify a set of generally applicable constraints whose variable ranking accounts for the patterns they find across Indo-Aryan and with respect to dialectal variation. In this, they build on Aissen's work, which is geared mostly towards accounting for the overt morphological realization of case, and combine this with arguments and proposals by Woolford (2001), who focuses more on the abstract realization of case.

Asudeh (2001) contributes to discussions on OT and case by taking on the question of how optionality should be dealt with within OT. This is an interesting problem as OT assumes there should be exactly one optimal candidate, not two or more. Asudeh focuses on data from Marathi as compiled by Joshi (1993), who shows that certain verb classes (mostly involving datives) allow for variable linking. In (30), for example, either one of the arguments could be linked to SUBJ, and the other is then linked to OBJ.

(30) sumaa-laa ek pustak milaale
Suma-DAT one book.NOM got
'Suma got a book.' Marathi

In order to account for this type of undisputed optionality in linking possibilities in Marathi, Asudeh makes use of the stochastic version of OT (Boersma 2000), which allows for the ranking of constraints on a continuous rather than a discrete scale and thus provides a way of allowing for optionality. Building on Joshi's original analysis, Asudeh works with Proto-Roles (see Section 6) to steer case assignment and takes up bidirectional OT in the discussion of OT approaches to optionality and, by extension, ambiguity.

Lee (2001a,b) focuses on word order freezing problems in two languages that otherwise allow fairly free scrambling of major constituents: Hindi and Korean. For example, in Hindi subjects and objects can in principle occur in any order, as illustrated by (31), in which the object is overtly marked as accusative, expressing specificity on the object.

(31) a. patt^{h}ar botal=ko toḍ-e-g-a
stone.NOM bottle=ACC break.3.SG-FUT-M.SG
'The stone will break the (particular) bottle.' Hindi

b. botal=ko patt^{h}ar toḍ-e-g-a
bottle=ACC stone.NOM break.3.SG-FUT-M.SG
'The stone will break the (particular) bottle.' Hindi

However, when both arguments have the same case marking the clause-initial argument must be interpreted as the subject, as illustrated in (32). This situation occurs when the object is also nominative (and thus non-specific in this Hindi DOM phenomenon) and if all else is equal, e.g., both arguments are equally non-animate as in (32).

(32) a. patt^{h}ar botal toḍ-e-g-a
stone.NOM bottle.NOM break.3.SG-FUT-M.SG
'The stone will break a/the bottle.' Hindi

b. botal patt^{h}ar toḍ-e-g-a
bottle.NOM stone.NOM break.3.SG-FUT-M.SG
'The bottle will break a/the stone.' Hindi

Lee works with notions of markedness in conjunction with bidirectional OT constraints to model phenomena such as these. The idea is that constraints from both the production and the comprehension side conspire together to allow for only clause-initial subjects in situations like (32) and that this working together of constraints makes visible the fact that unmarked word order in Hindi and Korean is SOV ("emergence of the unmarked").

Word order in Hindi and Korean has been shown to be associated with information structural effects and Lee's work accordingly includes a larger treatment of word order in terms of information structure. Lee proposes OT constraints which model the interaction of case marking, word order and discourse functions (e.g., topic and focus).

Like Lee, Dalrymple & Nikolaeva (2011) identify information structure as playing a central role in case marking phenomena. Unlike Lee, Dalrymple & Nikolaeva (2011) see the notion of topicality being directly linked to case marking and the innovation of case marking. Dalrymple & Nikolaeva (2011) take on DOM in a large swathe of languages and argue that the OT approaches to case pioneered by Aissen do not go deep enough and that information structural concerns must be taken to play a central role. They develop an alternative LFG analysis which uses LFG's projection architecture to model a complex interaction between c-structure, f-structure, i(nformation)-structure and semantic interpretation. The semantic component is modeled via glue semantics, see Asudeh forthcoming [this volume]. Dalrymple & Nikolaeva (2011) analyze a large variety of DOM in very different languages from this clausal semantic perspective on case. In more recent work, Donohue (2020) analyzes the case marking system of Fore, a Papuan language, by building on OT-LFG, Aissen's prominence scales and the bidirectional OT approach to case pioneered by Lee (2001a,b). The account focuses on instances of word order freezing and, more generally, on the strategies for case disambiguation found in Fore.

6 Clausal vs. Lexical Perspectives

LFG's original approach to linking, argument alternations and valency changing relations such as passives, applicatives or causatives were formulated to apply entirely within the lexicon, in keeping with LFG's primarily lexical perspective on syntax, cf. Findlay & Kibort forthcoming [this volume] and Section 3 of this chapter. Mohanan (1994), Butt (1995) and Alsina (1996) established that this lexical version of linking could not account for argument structure phenemona found with syntactically formed complex predicates. As a consequence, linking within LFG is no longer confined to apply within the lexicon.

In addition to this basic insight into the domain of linking, there is another dimension to the lexical vs. clausal divide which is relevant for an understanding of case. Case is classically understood as marking the relationship between a head and its dependents (Blake 2001). This relationship can be expressed entirely lexically. But, as we have already seen, case expresses much more than specifying how a dependent is related to a head/predicate. Section 5 on OT showed that case regularly marks degrees of agentivity, animacy and referentiality across a wide range of languages. Dalrymple & Nikolaeva (2011) furthermore conclusively demonstrate that information structure plays a large role in the development and structure of case systems, and we saw in the examples from Malayalam in (10) that case can be used to express modality. These semantic reflexes of case marking necessarily need to be taken into account, with Dalrymple & Nikolaeva (2011) rightly criticizing the existing OT accounts for being inherently too limited to provide a full account of the empirically attested patterns.

One underlying reason for this limitation is that while the OT accounts make reference to semantic concepts, they are primarily concerned with accounting for a structural relationship between the two core arguments of a clause (generally the SUBJ and OBJ) and the alternations found in case marking on these two core arguments. An approach to case which allows for the systematic expression of semantic dimensions in conjunction with structural considerations has been articulated clearly by Butt & King (2003, 2004) and has been recently extended in Schätzle (2018) and Beck & Butt (2021). As discussed in Section 7, this approach is quite complex and builds on a number of important semantic insights and formal ingredients. These are presented as part of this section.

6.1 Proto-Roles

Classic LFG's Mapping Theory works with thematic roles such as *agent, patient*, *goal*, etc. The use of such thematic role labels has repeatedly been shown to be problematic, with Grimshaw (1990) advocating for an approach that separates out arguments slots from semantic content and Dowty (1991) instead proposing to see predicate arguments as a collection of semantic entailments from which prototypical Agent vs. Patient roles can be defined. Van Valin (1991) and Van Valin & LaPolla (1997) propose a similar approach whereby the Macro-Roles Actor vs. Undergoer are defined on the basis of event-based properties (e.g., activities vs. results).

Taking these observations and proposals on board, Kibort has formulated a new version of LFG's Mapping Theory in a series of papers (Kibort 2007, 2013, 2014, Kibort & Maling 2015). This revised version adopts Grimshaw's idea of separating out argument slots from semantic content, but does not incorporate a notion of Proto-Roles. However, the idea of Proto-Roles has been adopted within LFG in a variety of other work, e.g., Alsina (1996), Asudeh (2001) and perhaps most significantly, by Zaenen (1993).

Zaenen shows how Dowty's collection of Proto-Agent vs. Proto-Patient semantic entailments as shown in (33) can be mapped onto LFG's existing Mapping Theory, which uses the features [±o,r] to relate GFs and thematic roles (see Findlay & Kibort forthcoming [this volume]). Zaenen's principles are shown in (34). These principles interact with other principles of LFG's Mapping Theory to ensure that [−o] marked participants are realized either as SUBJ or an OBL, [+o] marked participantes are linked to an OBJ or an OBJ_{θ}, etc.

(33) **Proto-Role Entailments**

Proto-Agent Properties

a. volitional involvement in the event or state
(Ex.: Kim in *Kim is ignoring Sandy.*)

b. sentience (and/or perception)
(Ex.: Kim in *Kim sees/fears Sandy.*)

c. causing an event or change of state in another participant (Ex.: loneliness in *Loneliness causes unhappiness.*)
d. movement (relative to the position of another participant) (Ex.: tumbleweed in *The tumbleweed passed the rock.*)
e. (exists independently of the event named by the verb) (Ex.: Kim in *Kim needs a new car.*)

Proto-Patient Properties

a. undergoes change of state (Ex.: cake in *Kim baked a cake.*, error in *Kim erased the error.*)
b. incremental theme (Ex.: apple in *Kim ate the apple.*)
c. causally affected by another participant (Ex.: Sandy in *Kim kicked Sandy.*)
d. stationary relative to movement of another participant (Ex.: rock in *The tumbleweed passed the rock.*)
e. (does not exist independently of the event, or not at all) (Ex.: house in *Kim built a house.*)

(34) **Association of Features with Participants** (Zaenen 1993:150,152)

1. If a participant has more patient properties than agent properties, it is marked −R.
2. If a participant has more agent properties than patient properties it is marked −O.
3. If a participant has an equal number of properties, it is marked −R.
4. If a participant has neither agent nor patient properties, it is marked −O.

Neither Kibort nor Zaenen deal with case marking per se. Zaenen applies her formalism to Dutch, which does not exhibit case. Kibort works with Slavic languages and Icelandic, which do have case, but she treats case as a piece of information which informs the linking, rather than as a phenomenon that needs to be explained. In contrast, Schätzle (2018) explicitly works on case and combines Kibort's revised linking theory with Zaenen's integration of Proto-Roles for her analysis of the diachronic trajectory of Icelandic dative subjects, see Section 7.

6.2 Clausal Semantics

The idea of Proto-Roles can in principle be applied within the lexicon to refer to the lexical semantics of the predicate. However, properties such as undergoing a change of state, being an incremental theme or attaining an endpoint along a path have by now been firmly established as resulting out of an interaction of the semantics of the Proto-Patient argument with the semantics of the event described by the verb (e.g., Krifka 1992, Verkuyl 1993). The quantizedness of the Proto-Patient argument has been shown to be crucial in determining the telicity of an event; more recently the effect is referred to in terms of scalarity (Hay et al. 1999, Kennedy & Levin 2008). The DCM alternation in (35) provides a representative example of this phenomenon in Finnish (also recall the Russian genitive alternation with respect to quantizedness discussed by Neidle, Section 2) When 'bear' is accusative, it definitely undergoes a change of state (dies) and the entire event is telic. In contrast, when one wishes to express that the intended endpoint of the action was not achieved, 'bear' appears in the partitive.

(35) a. Ammu-i-n karhu-n
shoot-PST-1SG bear-ACC
'I shot the/a bear.' (Kiparsky 1998: 267) Finnish

b. Ammu-i-n karhu-a
shoot-PST-1SG bear-PART
'I shot at the/a bear (bear is not dead).' (Kiparsky 1998: 267) Finnish

Ramchand (1997) discusses the Finnish data along with Scottish Gaelic alternations as in (36) and (37). She analyzes the differences in terms of boundedness. The alternation in (36) is essentially parallel to the Finnish example in (35). The alternation in (37) presents an interestingly different situation, but one that can also be analyzed in terms of boundedness: it expresses the difference between wanting something (unbounded) and getting it (bounded).

(36) a. tha Calum air na craobhan a ghearradh
be.PRS Calum ASP the trees.DIR OAGR cut.VN
'Calum has cut the trees.' Scottish Gaelic

b. tha Calum a' ghearradh nan craobhan
be.prs Calum ASP cut.VN the trees.GEN
'Calum is cutting the trees (no tree has necessarily been cut yet).' Scottish Gaelic

(37) a. tha mi air am ball iarraidh
be.prs I ASP the ball.DIR want.VN
'I have acquired the ball.' Scottish Gaelic

b. tha mi ag iarraidh a'bhuill
be.prs I asp want.vn the ball.gen
'I want the ball.' Scottish Gaelic

Ramchand (2008) extends and refines her analysis so that events are seen as being built up out of a tripartite structure consisting of an init(iation) subevent, a proc(ess) subevent and a res(ult) subevent. This tripartite structure contrasts with the more common bipartite approach found in the majority of event-based approaches to linking. For example, Jackendoff (1990) assumes a basic cause-become (init-res) relationship and makes provisions for activity verbs (proc), but does not combine all three subevent types into one tripartite template (see Levin & Rappaport Hovav 2005 for an overview), Ramchand demonstrates that her system works for a number of varied phenomena across languages and it has been adopted within LFG by Schätzle (2018) and Beck & Butt (2021), as discussed in the next section.

7 A Comprehensive Theory

This section first introduces an overall framework for case as developed by Butt and King in various papers (Section 7.1) and then goes on to look at the relationship between case and the theory of linking developed by Schätzle (2018) and Beck & Butt (2021) in Section 7.2.

7.1 Types of Case

Butt & King (2003, 2004) develop a theory of case that allows for four basic types: 1) structural case; 2) default case; 3) semantic case; 4) idiosyncratic case. This categorization differs significantly from other theories of case and is explained in some detail via examples in the next subsections. Notably, Butt and King's notion of semantic case is often conflated with idiosyncratic case in other theories and referred to as just one category of quirky/inherent case. Butt and King, on the other hand, argue that the two types need to be separated out for an effective understanding of case systems. Butt and King also define structural case as being that type of case which is only due to purely structural factors. The most common type of case marking in their system is that of semantic case, which exhibits a mix of systematic semantic and structural factors. Crucially, Butt and King center their analysis around an explanation of case alternations (including dcm) and consequently dub their theory *Differential Case Theory* or dct. Butt and King illustrate their analyses mainly with respect to Urdu, but also include data from Georgian.

7.1.1 Semantic Case: Mix of Structure and Semantics

Urdu has a complex system of case marking. Most of the case marking involves a mixture of structural and semantic factors as illustrated by the core examples in (38) and (39). Overt case marking generally takes the form of case clitics (see Butt & Ahmed Khan (2011) for a history of the development of case marking in Urdu) and the absence of any case marking is glossed as nominative (Mohanan 1994). The ergative is required with (di)transitive agentive verbs when the verb morphology is perfective, see (38a) vs. (38b). The accusative *ko* and the null nominative engage in DOM, with the accusative expressing specificity (Butt 1993) and generally required on animate objects, see (38a,b) vs. (38c).[10]

(38) a. nadya=ne gaṛi cɑla-yi hɛ
Nadya.F.SG=ERG car.F.SG.NOM drive-PFV.F.SG be.PRS.3.SG
'Nadya has driven a car.' Urdu

b. nadya gaṛi cɑla-ti hɛ
Nadya.F.SG.NOM car.F.SG.NOM drive-IPFV.F.SG be.PRS.3.SG
'Nadya drives a car.' Urdu

c. nadya=ne gaṛi=ko cɑla-ya hɛ
Nadya.F.SG=ERG car.F.SG=ACC drive-PFV.M.SG be.PRS.3.SG
'Nadya has driven the car.' Urdu

The Urdu ergative and accusative are structural in that they can only appear on subjects and objects, respectively. However, they are also semantically constrained in that they express object referentiality and animacy (accusative) and subject agentivity. The latter is illustrated by (39) where the presence of the ergative case on an unergative verb yields an 'on purpose' reading that is absent when the subject is nominative.

[10] Agreement in Urdu/Hindi works as follows. The verb will only agree with a nominative (unmarked) argument. If the SUBJ is unmarked, the verb agrees with this (38b), else the verb agrees with OBJ if that is unmarked (38a). If neither the SUBJ or the OBJ are available for agreement, the verb defaults to a masculine singular form, as in (38c). See Mohanan (1994) for a comprehensive discussion and Butt (2014) and references therein for information about verb agreement beyond the simple clause.

(39) a. ram kʰãs-a
Ram.M.SG.NOM cough-PFV.M.SG
'Ram coughed.'
(Tuite et al. 1985: 264) Urdu

b. ram=ne kʰãs-a
Ram.M.SG=ERG cough-PFV.M.SG
'Ram coughed (on purpose).'
(Tuite et al. 1985: 264) Urdu

Most case markers in Urdu exhibit this mix of structural and semantic properties and fall under the category of semantic case in DCT.

Butt and King model semantic case via an essentially lexical semantic approach to case in that they associate the relevant information directly with the case marker, specifying both the GF the case marker is compatible with and any attendant semantic information. This is illustrated for the accusative in (40).

(40) ko (↑ CASE) = acc
(OBJ ↑)
(↑SPECIFICITY) = +

Butt and King's approach uses inside-out functional designation like Nordlinger's Constructive Case approach (Section 4) and bears similarities to that approach in that case markers are taken to contribute to the overall analysis of the clause with information that goes beyond just the statement of what type of case is involved.[11] However, the approach goes beyond Constructive Case in providing a more complete view on the interaction between the lexical semantics of a verb, case semantics and structural case requirements.

7.1.2 Structural Case

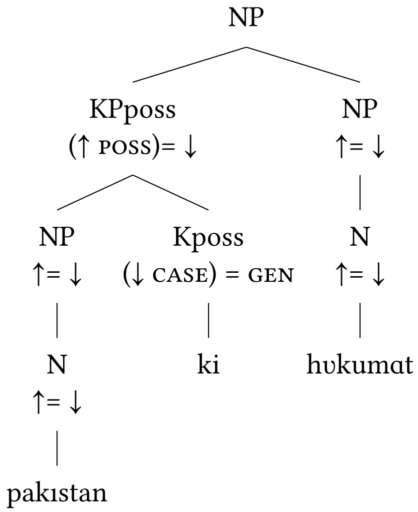
Examples of structural case tend to be restricted. In Urdu, an example of a purely structural case is the genitive in NPs, such as in (41), taken from Bögel & Butt (2012).

(41) pakıstan=ki hʊkumɑt
Pakistan=GEN.F.SG government.F.SG
'The government of Pakistan' Urdu

[11] Butt & King (2003, 2004) build on initial proposals by Butt & King (1991), foreshadowing Nordlinger's (1998) ideas on Constructive Case.

Genitive within NPs is assigned on purely structural grounds – there are no particular semantics associated with it. As in the early LFG approaches (Section 2) this type of case is therefore assigned only on the basis of c-structure configuration, by means of f-structure annotations on the appropriate c-structure nodes. An example, based on Bögel & Butt (2012), is provided in (42).

(42)



7.1.3 Reassessment of Quirky Case

Butt and King's category of semantic case separates out those case marking patterns which are associated with systematic semantic import from truly idiosyncratic case marking that needs to be stipulated (mostly as part of lexical entries). The dative is a prime example for a type of case that is often analyzed as an instance of quirky/inherent/idiosyncratic case despite the fact that it is demonstrably and very systematically associated with a certain semantic import (cf. the discussions in Section 2 and Section 3 above).

In Urdu the dative is also realized by the clitic *ko*. In its function as a dative, the *ko* can appear on indirect goal objects as in (43) and on experiencer subjects, as shown in (44).

(43)

nadya=ne	bɪlli=ko	dud	di-ya	hɛ
Nadya.F=ERG	cat.F.SG=DAT	milk.M.NOM	give-PFV.M.SG	be.PRS.3.SG

'Nadya has given milk to the cat.' Urdu

(44) nadya=ko ḍɑr lɑg-a
Nadya.F.SG=DAT fear.M.SG.NOM be attached-PFV.M.SG
'Nadya was afraid.' (lit. Fear is attached to Nadya.) Urdu

The dative alternates systematically with the ergative to express a contrast in agentivity, with the dative signaling reduced agency, generally giving rise to experiencer semantics as in (44) and (45a), but also to deontic modality as in (46a).

(45) a. nadya=ko kɑhani yad a-yi
Nadya.F.SG=DAT story.F.SG.NOM memory come-PFV.F.SG
'Nadya remembered the story.' Urdu

b. nadya=ne kɑhani yad k-i
Nadya.F.SG=ERG story.F.SG.NOM memory do-PFV.F.SG
'Nadya remembered the story (actively).' Urdu

(46) a. nadya=ko zu ja-na hɛ
Nadya.F.SG=DAT zoo.M.SG.OBL go-INF.M.SG be.PRS.3.SG
'Nadya has/wants to go to the zoo.' Urdu

b. nadya=ne zu ja-na hɛ
Nadya.F.SG=ERG zoo.M.SG.OBL go-INF.M.SG be.PRS.3.SG
'Nadya wants to go to the zoo.' Urdu

The systematic dative-ergative alternation as well as the tie in to modality indicates that these case patterns are not exclusively due to the lexically specified inherent semantics of a verb, but that the information associated with the case marker is making a significant contribution to the overall semantics of the clause. Generally, the dative marks goal arguments, whether these be recipients (43) or experiencers (44). In a very systematic alternation with the ergative, the dative signals reduced agentivity. The dative and its attendant signaling of reduced agency is pressed into service in the expression of modality in Urdu more generally, see Bhatt et al. (2011) for an overview of modals in Urdu/Hindi. The Urdu dative *ko* is thus also analyzed as an instance of semantic case in DCT.

7.1.4 Idiosyncratic Case

Idiosyncratic case is the type of case where no systematic generalizations, either of a structural or of a semantic kind, can be found. This is what distinguishes idiosyncratic case from both semantic and structural case. Instances of idiosyncratic case are typically due to diachronic developments that render the original reason for the case marking opaque, or which result in morphophonological changes that cause the case markers themselves to change and to be reclassified.

An example of truly idiosyncratic marking in Urdu is shown in (47). Recall that Urdu requires the ergative on subjects of agentive transitive perfect verbs. However, while the verb 'bring' in (47) falls into this category, its subject is nominative.

(47) nadya kıtab la-yi
Nadya.F.SG.NOM book.F.SG.NOM bring-PFV.F.SG
'Nadya brought a book.'

There are no other straightforwardly agentive transitive verbs which behave like this, so this exceptional and idiosyncratic nominative case must be stipulated as part of the lexical entry of *la* 'bring'. Another exceptional verb is *bol* 'speak', which is unergative and should therefore allow for an ergative subject in the perfective, but does not.

7.1.5 Default Case

Finally, Butt and King also provide for default case marking. Default case marking occurs when an NP is not already specified for a case feature via some part of the grammar (lexicon, syntax). In languages which require all NPs to be case marked, such NPs receive a default case. In Urdu the default case is the phonologically null nominative, which can only appear on subjects and objects. Default case can be assured via well-formedness statements in the functional annotations on the NP node at c-structure, as shown in (48).

(48)
1. Wellformedness principle: NP: (↑ CASE)
2. Default: (↑ SUBJ CASE)=NOM
3. Default: (↑ OBJ CASE)=NOM

These rules constrain every NP to be associated with a case feature and to make sure that subjects and objects are assigned nominative case in the absence of any other specification. Basically the annotations check if there is a case feature realized. If not, then nominative is assigned by default. This type of if-then realization of functional annotations is slightly more complex than illustrated in (48), which is kept simple for purposes of illustration. A full implementation can be found in the Urdu ParGram grammar (Butt & King 2002, Bögel et al. 2009).

7.2 Event-based Linking

The theory in Section 7.1 as to the types of case that must be accounted for does not make reference to linking. However, a theory of linking is clearly also needed as it determines how the event semantics of a verb plays out in terms of syntactic valency and case marking. We saw in Section 6 that an *event-based* approach is necessary for an understanding of DCM patterns (e.g., for telicity or boundedness/scalarity more generally). An event-based approach is also what underlies the generally accepted ideas behind Dowty's Proto-Roles or Van Valin's Macro-Roles, as the prototypical Agent/Patient properties are defined in terms of how the participant is related to the event being described (change of state is being effected, one participant is stationary with respect to another participant, etc.).

Event-based approaches to linking are common (e.g., Jackendoff 1990, Van Valin & LaPolla 1997, Rappaport Hovav & Levin 1998, Croft 2012, see Levin & Rappaport Hovav (2005) for an overview), but are employed within LFG only in a subset of linking approaches. This occurs either indirectly via the incorporation of a notion of Proto-Roles, or explicitly in adaptations of Jackendoff's Lexical-Conceptual Structures, as done by Butt (1995).

Kibort's revised version of Mapping Theory improves on the classic version of mapping within LFG by separating out argument slots from semantic content and formulating new mapping principles that make reference to semantics (Kibort 2014). However, semantic principles are made use of only occasionally and relatively indirectly.

Schätzle (2018) bases herself on Kibort's revised Mapping Theory but brings in semantic information explicitly on several dimensions. Importantly, she adopts Ramchand's (2008) tripartite division of events into three types of subevents: init(iation), proc(ess), res(ult). This event semantic dimension is used to derive Proto-Role properties and these in turn are used to determine the linking between argument slots and GFs. Schätzle also integrates a Figure/Ground dimension. This is intended to do justice to the information-structural effects found with respect to case. However, she does not need the full-fledged representation of information-structure developed by Dalrymple & Nikolaeva (2011), instead adopting the basic Figure/Ground distinction first developed by Talmy (1978).

Schätzle's basic system is illustrated below with respect to the Icelandic example in (49), which is taken from Beck & Butt (2021) and represents a revised version of the original in Schätzle (2018).

(49) Gunnar fann seint hrossin um daginn
Gunnar.NOM find.PST.3SG late horse.PL.DEF.ACC during day.DEF.ACC
'Gunnar found the horses late during the day.'

(IcePaHC, 1400.GUNNAR.NAR-SAG,.281)

		init	proc		res	rh	
find	<		x_*Gunnar*		x_*horses*		>
			FIGURE		GROUND		
			P-A:***, P-P:*		P-P:**		
			SUBJ		OBJ		
			nominative		accusative		

The main predicate here is *finna* 'find', which expresses a dynamic event. The event consists of an initiation of the event, a process during which the event takes place and a result. The initiator of the event is 'Gunnar' so this role is linked to the init subevent. The initiator is also the participant involved in the event as it unfolds, so is also linked to the proc subevent. The 'horses' argument is linked to the result subevent as finding the horses represents the successful culmination of the event. As a sentient initiator that is also the Figure of the clause, Gunnar thus picks up three Proto-Agent (P-A) properties (sentience, init, Figure). As an undergoer of a process, Gunnar receives one Proto-Patient (P-P) property (the occurrence and number of Proto-Role properties is indicated via the number of of '*' on the features P-A and P-P). The 'horses' argument is the Ground and the resultee and as such picks up two Proto-Patient properties and no Proto-Agent properties. The participant with the most Proto-Agent properties is linked to the SUBJ, leaving the horses to be linked to OBJ. The case marking on the SUBJ and OBJ in this case is an instance of default case: the subject is nominative and the object is accusative in the absence of any other specification.

Schätzle (2018) is primarily concerned with investigating the diachronic increase in the occurrence of dative subjects in Icelandic. Using corpus linguistic methodology, she pinpoints the lexicalization of former middles as experiencer verbs as a major reason for the increased use of dative subjects in Icelandic. One of the verbs that has undergone such lexicalization is the verb *finna* 'find', featured in (49). This was reanalyzed as a stative experiencer and raising predicate via middle formation with the middle morpheme *-st* in the history of Icelandic and came to mean 'find, feel, think, seem'.

Schätzle (2018) shows how this process of reanalysis can be understood as a form of locative inversion. There are several steps to this posited diachronic change. First, consider the linking configuration for the middle version of the example in (49), as shown in (50). Under middle formation, *finna* becomes *finna-st*, meaning 'be found, meet', and the initiation subevent is absent for the purposes of linking. The middle predication essentially describes a result, which is that there are found horses.

(50) The horses were found at the lake.

		init	proc	res	rh (loc)	
find$_{middle}$	<			x_*horses*	x_*lake*	>
				FIGURE	GROUND	
				P-A:*, P-P:*	P-P:*	
				SUBJ	OBL	
				nominative	dative	

Schätzle also adopts Ramchand's (2008) notion of a *rh(eme)*. A rheme serves as a complement slot that modifies the core predication. In (50) this rheme slot is occupied by the locative 'at the lake'. Rhemes are generally not compatible with the Figure role, they provide a Ground argument. So in (50) 'horses' acts as the Figure, picking up one Proto-Agent property. This argument is linked to the result subevent, which yields one Proto-Patient property. The horses thus have more Proto-Agent properties (one) than the lake (none) and so the horses are linked to SUBJ. The rheme is also a locative and this configuration yields a linking to OBL. The SUBJ is nominative per default, the OBL is marked with the Icelandic spatial dative.

The configuration in (50) in fact very closely resembles that of a straightforwardly stative predication, which is also one possible interpretation of the middle form of 'find'. In this case it means something along the lines of 'be situated/located'. Schätzle posits that in this case the original result participant is interpreted as the holder of a state. The holder of a state is linked to the init subevent in Ramchand's system. As shown in (51), there is no change in the overall linking configuration and the attendent case marking, but there is a change in the interpretation of the event semantics: (51) shows a stative predication rather than the result part of a dynamic event.

(51) The horses were (located/situated) at the lake.

		init (holder)	rh	
find$_{middle}$ *(stative)*	<	x *_horses*	x *_lake*	>
		FIGURE	GROUND	
		P-A:*, P-P:*	P-P:*	
		SUBJ	OBL	
		nominative	dative	

Schätzle postulates that over time, this type of stative predication via middle formation led to lexicalized experiencer predicates as in (52), where *finna* means 'feel'. These experiencer predicates feature a dative SUBJ synchronically and Schätzle proposes that the dative SUBJ is the result of a flip in the linking relation that occurred when the Ground argument is sentient, as shown in the linking configurations in (52). The first configuration corresponds to a literal locative reading of 'The night was found at him.' and shows the same relations as in (51), just with a sentient Ground. But this small difference results in an equal distribution of Proto-Role properties across the two event participants. This taken together with a crosslinguistic preference for sentient participants to be interpreted as a Figure rather than as a Ground leads to an unstable linking configuration.

(52) og fannst honum nótt.
and feel.PST.MID.3SG he.DAT night.NOM
'and he felt the night.'
(IcePaHC, 1861.ORRUSTA.NAR-FIC,.1670)

		init (holder)	rh	
find$_{middle}$	<	x *_night*	x *_he*	>
		FIGURE	GROUND	
		P-A:*, P-P:*	P-A:*,P-P:*	
		SUBJ	OBL	
		nominative	dative	

	init (holder)	rh	
feel <	x*_he*	x*_night*	>
	FIGURE	GROUND	
	P-A:**, P-P:*	P-P:*	
	SUBJ	OBJ	
	dative	nominative	

This unstable linking configuration can be resolved by flipping the Figure/Ground relations and associating the sentient argument with the holder of the state, as shown in the lower linking configuration. With this simple configurational change, the sentient argument now picks up two Proto-Agent properties (Figure and sentience), and one Proto-Patient property as a holder of a state. The other argument receives only one Proto-Patient property as the Ground. The overall effect ist that the sentient argument is now linked to SUBJ, the other (non-spatial) argument to OBJ. The originally spatial dative marking is retained on the newly minted SUBJ and feeds into a general pattern of dative marked experiencer subjects in the language.

Beck & Butt (2021) use the same analysis of locative inversion to account for patterns of dative subjects in Indo-Aryan. Their approach also provides an account for the Marathi optional dative subjects discussed by Asudeh (2001) and in Section 5 of this chapter. In Beck and Butt's account the observed optionality is attributed to an unstable linking configuration of the type shown in the upper part of (52). This leads to an optionality that is slowly resolved over time in favor of a dative subject constellation as shown in the lower part of (52). Deo (2003) shows that this is the change that is indeed happening in Marathi, verb class by verb class, verb by verb.

Overall, in this event-based approach to linking, case is matched with certain linking configurations. For example, in Icelandic and Marathi, the holder of a state as in the lower linking configuration in (52) must systematically be associated with a dative and this expresses experiencer semantics.

8 Summary

This chapter has surveyed LFG work on case from some of the earliest LFG papers to some of the most recent developments. The LFG perspective, particularly with respect to Icelandic, was instrumental in establishing a basic division between structural and lexically specified case, where the latter also came to be known as 'quirky' case. Later work put the relationship between predicate arguments and GF on a more systematic footing via the formulation of Mapping Theory. Case was always relevant for Mapping, but not integrated into the theory itself. The event-based linking developed by Schätzle (2018) and Beck & Butt (2021) offers a more natural way of integrating case information, while also building on Kibort's revised Mapping Theory and allowing for an integration of Proto-Role properties. The integration of such Proto-Role properties into accounts of case and linking have been experimented with in a number of ways within LFG over the years, especially in terms of work done within OT-LFG.

Butt and King formulate a theory of case, which distinguishes between four types of case: 1) structural, 2) default, 3) semantically generalizable and 4) idiosyncratic. Their notion of semantic case centrally applies to core arguments of a verb and includes accounts of Differential Case Marking, including modality. Case markers are considered to have their own lexical entries and to be associated with syntactic and semantic information which contributes to the overall syntactic and semantics analysis of the clause. This is in line with Nordlinger's idea of Constructive Case, which can additionally account for case stacking.

This chapter has not included a comparison of LFG with other theories. In terms of linking, LFG employs a distinct version, but the essence of, and the insights behind, linking have very much in common with other theories of the interface between lexical semantics and syntax. The same is true for the OT-LFG approaches to case, which build directly on mainstream OT insights and proposals. However, as far as I am aware, the idea of Constructive Case and the four-way distinction between different types of case is unique to LFG.

Abbreviations

Besides the abbreviations from the Leipzig Glossing Conventions, this chapter uses the following abbreviations.

A	agent	O	object
ASP	aspectual marker	OAGR	object agreement
DIR	directional	PART	partitive
I	Class I	PRON	pronoun
MID	middle	PROP	proprietive
MOD	modal	VN	verbal noun.

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Chapter 3

Coordination

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Coordination is a rich and complex topic. To avoid repeating what has been written in many excellent textbooks and reference guides, this chapter takes a non-standard approach. It starts by presenting the very basics of coordination in LFG, it provides pointers to agreement phenomena related to coordination, and then it proceeds to discuss selected less well-known coordination phenomena and their treatment in LFG, including: non-constituent coordination, coordination of unlike categories, coordination of unlike grammatical functions and coordination involving ellipsis.

1 Introduction

This section starts by introducing two key concepts of coordination in LFG: sets and hybrid objects. Next, it briefly introduces distributivity, a key concept of coordination, on the basis of feature resolution (for non-distributive attributes) and dependent sharing (for grammatical functions, which belong to distributive attributes). Finally, it presents single conjunct agreement as an alternative to resolved agreement (under feature resolution).

Over time, different conventions have been used in f-structures. To avoid potential confusion, the f-structures presented in this chapter have been normalized: as a result, while f-structures in this chapter consistently use the same conventions, they may look different than in original papers. Furthermore, to save space, some f-structures are simplified by removing attributes which are not relevant in a given context (such as SPEC, for instance).

The following convention is used in c-structure rules in this chapter: if a category on the right-hand side has no annotation, it is assumed to have the (co-)head annotation (↓=↑).

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Except for (189), all examples used in this chapter are either English or Polish.

1.1 Coordination basics: sets and hybrid objects

A basic LFG coordination rule is given in (1), where XP is a variable over categories: every instance of XP in (1) must be replaced by the same category (for example NP).

(1) XP ⟶ XP Conj XP
↓∈↑ ↓∈↑

While the rule in (1) can only join two conjuncts, its slightly modified version in (2) can join more than two conjuncts: XP^+ corresponds to one or more occurrences of XP.[1] Furthermore, the rule in (2) includes an optional preconjunction (such as BOTH in *both… and…* or EITHER in *either… or…*):[2]

(2) XP ⟶ (PreConj) XP^+ Conj XP
↓∈↑ ↓∈↑

While there are various patterns of coordination (one conjunction, as many conjunctions as conjuncts, one fewer conjunction than the number of conjuncts, etc.), the basic annotations are the same: any (pre)conjunctions are co-heads (↓=↑, omitted above following the convention that lack of annotation is equivalent to having ↓=↑ annotation), while conjuncts are members of the set (↓∈↑) corresponding to the coordinate structure.

Let us consider structures created by these rules, using the simplified lexical entries below:

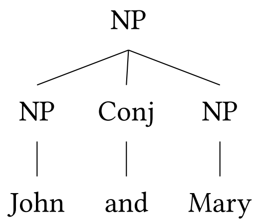
(3)

John	N	(↑ PRED)=‘JOHN’
Mary	N	(↑ PRED)=‘MARY’
and	Conj	(↑ CONJ)=AND
both	PreConj	(↑ PRECONJ)=BOTH
		(↑ CONJ)$=_c$ AND

The structures in (4)–(5) can be generated by both rules in (1) and (2), while the structures with the preconjunction in (6)–(7) can only be generated by the rule in (2).

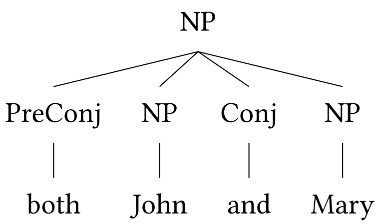
[1] Punctuation between non-final conjuncts is ignored in (2).
[2] While (2) overgenerates (*both… and…* can only be used with two conjuncts), some speakers can use *either… or…* with more than two conjuncts (e.g. *either X, Y or Z*).

(4)



(5) $\left[\begin{array}{l}\left\{\left[\textsc{pred}\ \text{‘}\textsc{John}\text{’}\right], \left[\textsc{pred}\ \text{‘}\textsc{Mary}\text{’}\right]\right\} \\ \textsc{conj}\quad \textsc{and}\end{array}\right]$

(6)



(7) $\left[\begin{array}{l}\left\{\left[\textsc{pred}\ \text{‘}\textsc{John}\text{’}\right], \left[\textsc{pred}\ \text{‘}\textsc{Mary}\text{’}\right]\right\} \\ \textsc{preconj}\quad \textsc{both} \\ \textsc{conj}\quad \textsc{and}\end{array}\right]$

The f-structures representing coordination are hybrid objects. This is because they contain two types of objects: a set containing the individual conjuncts (sets are represented using curly brackets; set elements may be typeset horizontally or vertically) as well as attributes pertaining to the coordinate structure as a whole (these include the attributes CONJ and PRECONJ[3] representing the conjunction and the preconjunction, respectively).

1.2 Non-distributivity and feature resolution

As mentioned above, the lexical entries in (3) are simplified. The importance of hybrid objects is clearer when more features are represented in the f-structure, so let us extend the lexical entries in (8) by adding the NUM(ber) feature (while still ignoring other features):

(8)	*John*	N	($\uparrow$ PRED)=‘JOHN’
			($\uparrow$ NUM)=SG
	Mary	N	($\uparrow$ PRED)=‘MARY’
			($\uparrow$ NUM)=SG

[3]Some works use different attribute names, for instance COORD-FORM and PRECOORD-FORM.

As shown in (9),[4] even though both conjuncts are singular, the coordinate subject as a whole is plural – as a consequence, the verb requires plural agreement:

(9) [[John] and [Mary]] sing/*sings.

(10)

sing	V	(↑ PRED)='SING⟨(↑ SUBJ)⟩' (↑ SUBJ NUM) $=_c$ PL
sings	V	(↑ PRED)='SING⟨(↑ SUBJ)⟩' (↑ SUBJ NUM) $=_c$ SG

(11) shows how this is reflected in the f-structure: while individual conjuncts are singular (their value of NUM is SG), the entire coordination is plural (its NUM is PL):

(11)
$$\begin{bmatrix} \left\{ \begin{bmatrix} \text{PRED} & \text{`JOHN'} \\ \text{NUM} & \text{SG} \end{bmatrix}, \begin{bmatrix} \text{PRED} & \text{`MARY'} \\ \text{NUM} & \text{SG} \end{bmatrix} \right\} \\ \text{NUM} \quad \text{PL} \\ \text{CONJ} \quad \text{AND} \end{bmatrix}$$

To obtain such a representation, the equation (↑ NUM)=PL must be placed somewhere in the grammar. While normally it would be part of more complex feature resolution rules for number,[5] it is put below in the simplified rule handling NP coordination, see (12).

(12)
$$\text{NP} \longrightarrow \text{(PreConj)} \quad \underset{\downarrow\in\uparrow}{\text{NP}^{+}} \quad \underset{\substack{\downarrow=\uparrow \\ (\uparrow\ \text{NUM})=\text{PL}}}{\text{Conj}} \quad \underset{\downarrow\in\uparrow}{\text{NP}}$$

The prerequisite for this equation to work as desired is that the NUM attribute must be non-distributive. This means that such an equation does not distribute to individual conjuncts (which would clash with (↑ NUM)=SG in their lexical entries), but instead it applies to the topmost f-structure corresponding to the entire coordinate phrase, see (11).

Apart from NUM(ber), some typical non-distributive attributes (or features) include GEND(er) and PERS(on). As mentioned above for NUM(ber), such non-distributive attributes are subject to feature resolution: rules specifying which value of these attributes is appropriate for the entire coordinate phrase, given the values of these attributes of particular conjuncts. Feature resolution rules are different for various attributes and may differ across languages. See Haug forthcoming [this volume] for more discussion and references.

[4] Square brackets in examples indicate the boundaries of coordination and individual conjuncts.

[5] Such rules should consider the type of the conjunction (*and* vs. *or*). Even with *and*, it is not always the case that the number should be plural: *my doctor and best friend* can refer to one or two individuals.

1.3 Distributivity and dependent sharing

The rules in (1)–(2) can also be used to join categories other than NPs. For instance, (13) involves coordination of two sentences, while (14) involves two instances of coordination, at two different levels: NP coordination (*John and Mary*) described above (with the more specialised rule in (12)), and coordination of verbal phrases (*sing and walk*).

(13) [[John sings] and [Mary walks]].

(14) [[John] and [Mary]] [[sing] and [walk]].

In (14) the coordinated nominal subject (*John and Mary*, see its partial f-structure in (5)) is a shared dependent of the coordinated verbal phrases (*sing and walk*, see (15)).

(15)
$$\begin{bmatrix} \left\{ \begin{bmatrix} \text{PRED} & \text{`SING}\langle\text{SUBJ}\rangle\text{'} \end{bmatrix}, \begin{bmatrix} \text{PRED} & \text{`WALK}\langle\text{SUBJ}\rangle\text{'} \end{bmatrix} \right\} \\ \text{CONJ} \quad \text{AND} \end{bmatrix}$$

Since grammatical functions are distributive, no special rules are required to handle examples with a shared dependent such as (14). The equation $(\uparrow \text{SUBJ}){=}\downarrow$ assigning the SUBJ grammatical function to the NP in (16) distributes to each element of the set corresponding to the VP.[6] As a result, (5) becomes the subject of both conjuncts in (15), yielding (17) which involves structure sharing, indicated using boxed indices ($\boxed{1}$).

(16)
$$\begin{array}{cccc} \text{S} & \longrightarrow & \text{NP} & \text{VP} \\ & & (\uparrow \text{SUBJ}){=}\downarrow & \end{array}$$

(17)
$$\begin{bmatrix} \left\{ \begin{bmatrix} \text{PRED} & \text{`SING}\langle\boxed{1}\rangle\text{'} \\ \text{SUBJ}\ \boxed{1} & \begin{bmatrix} \left\{ \begin{bmatrix} \text{PRED} & \text{`JOHN'} \\ \text{NUM} & \text{SG} \end{bmatrix}, \begin{bmatrix} \text{PRED} & \text{`MARY'} \\ \text{NUM} & \text{SG} \end{bmatrix} \right\} \\ \text{NUM} \quad \text{PL} \\ \text{CONJ} \quad \text{AND} \end{bmatrix} \end{bmatrix}, \begin{bmatrix} \text{PRED} & \text{`WALK}\langle\boxed{1}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \end{bmatrix} \right\} \\ \text{CONJ} \quad \text{AND} \end{bmatrix}$$

[6] Most recent analyses would use IP instead of S and I′ instead of VP. However, since these distinctions are not the main focus of this chapter, the rules and c-structures from the literature are not normalised.

1.4 Single conjunct agreement

Single conjunct agreement (SCA) is an alternative agreement strategy available under coordination in some languages. Instead of agreeing with the entire coordinate phrase under feature resolution, under SCA the agreement target (for example: the verb) agrees with one of the conjuncts of its agreement controller (for verbs, typically the subject), usually the closest conjunct – this is known as closest conjunct agreement (CCA). Though furthest conjunct agreement (FCA) is also attested, it is rather rare (compared to CCA).

(18) is a Polish example showing resolved agreement (*szli* 'walked' is plural masculine) as opposed to agreement with the closest conjunct (*szła* 'walked' is singular and feminine):

(18) Polish
Szli/szła [[Marysia] i [Janek]].
walked.3.PL.M1/3.SG.F Marysia.SG.F and Janek.SG.M1
'Janek and Marysia walked.'

See Haug forthcoming [this volume] for more discussion of SCA and references.

2 Non-constitutent coordination

When discussing coordination, typically what is discussed is coordination of constituents (typically of the same category and corresponding to the same grammatical function). Kaplan & Maxwell (1988) is the first published LFG analysis of such coordination.

Maxwell & Manning (1996) is a seminal LFG work discussing non-constituent coordination (NCC) where conjuncts do not correspond to constituents. Instead, each conjunct corresponds to a sequence of constituents (or possibly their parts), with no strict requirement of parallelism between conjuncts. Maxwell & Manning (1996: 1) provide the following "grab-bag of other cases of coordination commonly negatively classified as non-constituent coordination" which are outside of the scope of Kaplan & Maxwell (1988), labelling (19) as "conjunction reduction" (CR), (20) as "Right-Node Raising" (RNR), (21) as "Gapping", (22) as "Ellipsis" and (23) as "non-symmetric coordination":

(19) Bill gave [[the girls spades] and [the boys recorders]].
(Maxwell & Manning 1996: (2a))

(20) [[Bill likes], and [Joe is thought to like]] cigars from Cuba.
(Maxwell & Manning 1996: (2b))

(21) [[Bill gave a rhino to Fred], and [Sue a camera to Marjorie]].
(Maxwell & Manning 1996: (2c))

(22) [[Bill likes big cars], and [Sally does too]].
(Maxwell & Manning 1996: (2d))

(23) Bill [[went] and [took the test]]. (Maxwell & Manning 1996: (2e))

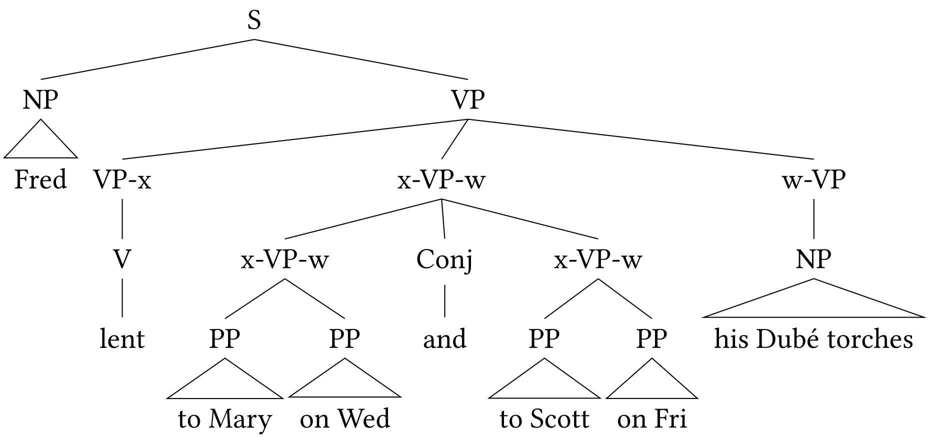
In order to account for instances of CR and RNR, Maxwell & Manning (1996: 3) propose to extend the analysis of coordination by allowing "the coordination of partial expansions of c-structure rules", namely partial expansions of VP rules (such as (26) discussed below), pointing out that this solution makes it possible to "maintain the simple and classic rule for coordination that only identical things are allowed to coordinate".[7]

2.1 Basics of the Maxwell & Manning (1996) analysis

Let us consider (24), where the NCC (*to Mary on Wednesday and to Scott on Friday*)[8] is surrounded by shared material: the subject (*Fred*) and the main verb (*lent*) on the left and the object on the right (*his Dubé torches*). (25) is the tree corresponding to (24).

(24) Fred lent [[to Mary on Wednesday] and [to Scott on Friday]] his Dubé torches.

(25)



(Maxwell & Manning 1996: (15))

[7] It can also be used to reanalyse unlike category coordination as same category coordination, see Section 3.1.

[8] *Wednesday* and *Friday* are abbreviated in trees and f-structures to *Wed* and *Fri*, respectively.

The following modified rules can be read off the tree in (25):[9]

(26) VP $\longrightarrow$ VP-x x-VP-w w-VP

(27) VP-x $\longrightarrow$ V

(28) x-VP-w $\longrightarrow$ x-VP-w Conj x-VP-w

(29) x-VP-w $\longrightarrow$ PP PP

(30) w-VP $\longrightarrow$ NP

However, the rules above are not complete because f-descriptions are missing. While the rule in (31) could normally be used, in order to handle the NCC in (24), the rules in (28)–(30) must be annotated with f-descriptions as shown in (32)–(34):

(31)
$$\begin{array}{llllll} \text{VP} & \longrightarrow & \text{V} & \text{PP} & \text{PP}^{*} & \text{NP} \\ & & & (\uparrow \textsc{obl}){=}\downarrow & \downarrow{\in}(\uparrow \textsc{adj}) & (\uparrow \textsc{obj}){=}\downarrow \end{array}$$

(32)
$$\begin{array}{lllll} \text{x-VP-w} & \longrightarrow & \text{x-VP-w} & \text{Conj} & \text{x-VP-w} \\ & & \downarrow{\in}\uparrow & & \downarrow{\in}\uparrow \end{array}$$

(33)
$$\begin{array}{llll} \text{x-VP-w} & \longrightarrow & \text{PP} & \text{PP} \\ & & (\uparrow \textsc{obl}){=}\downarrow & \downarrow{\in}(\uparrow \textsc{adj}) \end{array}$$

(34)
$$\begin{array}{lll} \text{w-VP} & \longrightarrow & \text{NP} \\ & & (\uparrow \textsc{obj}){=}\downarrow \end{array}$$

There is an important difference between “standard” rules such as (31) and modified rules aimed at handling NCC. While in (31) subsequent dependents have appropriate grammatical function annotations (($\uparrow$ OBL)=$\downarrow$ for the oblique PP, $\downarrow\in$($\uparrow$ ADJ) for the modifier PP and ($\uparrow$ OBJ)=$\downarrow$ for the NP object), the corresponding NCC partial categories in (26), x-VP-w and w-VP, have no annotation, which is interpreted by default as the co-head annotation ($\downarrow$=$\uparrow$). As a consequence, the annotations assigning appropriate grammatical functions are instead equivalently placed in (33) (for x-VP-w which rewrites to an oblique PP followed by a modifier PP) and in (34) (for w-VP which rewrites to an NP object). Thanks to the different placement of f-descriptions,[10] such modified rules can account for NCC, unlike the “standard” VP rule in (31).

[9] While Maxwell & Manning (1996) use “and” in their rules, it was replaced with “Conj” for consistency.

[10] Moving f-descriptions in this way is crucial in some analyses of other phenomena discussed later, including coordination of different grammatical functions (Section 4) and gapping (Section 5.3).

To better understand the analysis of Maxwell & Manning (1996), let us consider its procedural intuition by inspecting partial f-structures created by these rules.

Each conjunct of NCC builds its partial f-structure using the rule in (33): (35) corresponds to the first conjunct (*to Mary on Wednesday*), (36) to the second (*to Scott on Friday*).

(35)
$$\left[\begin{array}{ll} \textsc{obl} & \left[\textsc{pred}\ \text{`Mary'}\right] \\ \textsc{adj} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{on}\langle\boxed{1}\rangle\text{'} \\ \textsc{obj} & \boxed{1}\left[\textsc{pred}\ \text{`Wed'}\right]\end{array}\right]\right\}\end{array}\right]$$

(36)
$$\left[\begin{array}{ll} \textsc{obl} & \left[\textsc{pred}\ \text{`Scott'}\right] \\ \textsc{adj} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{on}\langle\boxed{2}\rangle\text{'} \\ \textsc{obj} & \boxed{2}\left[\textsc{pred}\ \text{`Fri'}\right]\end{array}\right]\right\}\end{array}\right]$$

Next, (35) and (36) are added as set elements using the coordination rule in (32).[11]

(37)
$$\left[\begin{array}{l} \left\{\left[\begin{array}{ll} \textsc{obl} & \left[\textsc{pred}\ \text{`Mary'}\right] \\ \textsc{adj} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{on}\langle\boxed{1}\rangle\text{'} \\ \textsc{obj} & \boxed{1}\left[\textsc{pred}\ \text{`Wed'}\right]\end{array}\right]\right\}\end{array}\right], \left[\begin{array}{ll} \textsc{obl} & \left[\textsc{pred}\ \text{`Scott'}\right] \\ \textsc{adj} & \left\{\left[\begin{array}{ll}\textsc{pred} & \text{`}\textsc{on}\langle\boxed{2}\rangle\text{'} \\ \textsc{obj} & \boxed{2}\left[\textsc{pred}\ \text{`Fri'}\right]\end{array}\right]\right\}\end{array}\right]\right\} \\ \textsc{conj}\quad \textsc{and}\end{array}\right]$$

Next, the VP rule in (26) unifies the partial f-structures of 3 co-heads: (38) corresponds to VP-x; (37) is the set corresponding to NCC in x-VP-w; (39) is created by the w-VP rule in (34). As mentioned in Section 1.3 when discussing (14), grammatical functions are distributive; so is PRED. Note that being a distributive feature is consistent with being an instantiated feature: when PRED is distributed, it is uniquely instantiated in each conjunct.[12] As a result, (38) and (39) distribute over (37), yielding the f-structure in (40).

(38)
$$\left[\textsc{pred}\ \text{`}\textsc{lend}\langle\textsc{subj},\textsc{obj},\textsc{obl}\rangle\text{'}\right]$$

(39)
$$\left[\textsc{obj}\ \left[\textsc{pred}\ \text{`Dubé torches'}\right]\right]$$

[11] Coordination of partial expansions such as in (32) is handled by the general coordination rule in (1).

[12] This makes it possible to account for multiclausal coordination phenomena such as NCC, coordination of different grammatical functions (Section 4.4), SGF (Section 5.1) and gapping (Section 5.3).

(40)

$$\left[\begin{array}{l} \left\{\begin{array}{l} \left[\begin{array}{ll} \text{PRED} & \text{`LEND}\langle\text{SUBJ},\boxed{2},\boxed{3}\rangle\text{'} \\ \text{OBJ} & \boxed{2}\left[\text{PRED `DUBÉ TORCHES'}\right] \\ \text{OBL} & \boxed{3}\left[\text{PRED `MARY'}\right] \\ \text{ADJ} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{4}\rangle\text{'}\\ \text{OBJ} & \boxed{4}\left[\text{PRED `WED'}\right]\end{array}\right]\right\} \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`LEND}\langle\text{SUBJ},\boxed{2},\boxed{5}\rangle\text{'} \\ \text{OBJ} & \boxed{2} \\ \text{OBL} & \boxed{5}\left[\text{PRED `SCOTT'}\right] \\ \text{ADJ} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{6}\rangle\text{'}\\ \text{OBJ} & \boxed{6}\left[\text{PRED `FRI'}\right]\end{array}\right]\right\} \end{array}\right] \end{array}\right\} \\ \text{CONJ} \quad \text{AND} \end{array}\right]$$

One element is missing in (40): the shared subject (*Fred*), see the tree in (25). Assuming a rule for S such as in (16), the annotation (↑ SUBJ)=↓ distributes the NP subject over the partial f-structure in (40), yielding the complete f-structure in (41).

(41)

$$\left[\begin{array}{l} \left\{\begin{array}{l} \left[\begin{array}{ll} \text{PRED} & \text{`LEND}\langle\boxed{1},\boxed{2},\boxed{3}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED `FRED'}\right] \\ \text{OBJ} & \boxed{2}\left[\text{PRED `DUBÉ TORCHES'}\right] \\ \text{OBL} & \boxed{3}\left[\text{PRED `MARY'}\right] \\ \text{ADJ} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{4}\rangle\text{'}\\ \text{OBJ} & \boxed{4}\left[\text{PRED `WED'}\right]\end{array}\right]\right\} \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`LEND}\langle\boxed{1},\boxed{2},\boxed{5}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \\ \text{OBJ} & \boxed{2} \\ \text{OBL} & \boxed{5}\left[\text{PRED `SCOTT'}\right] \\ \text{ADJ} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{6}\rangle\text{'}\\ \text{OBJ} & \boxed{6}\left[\text{PRED `FRI'}\right]\end{array}\right]\right\} \end{array}\right] \end{array}\right\} \\ \text{CONJ} \quad \text{AND} \end{array}\right]$$

An important thing to note about the Maxwell & Manning (1996) analysis of NCC is that it creates multiclausal structures.[13] This means that it is equivalent to a coordination of two VPs, with two instances of a given verb – it is clear in (41), where the set corresponding to coordination contains two clauses with different instantiations of LEND as the main verb.

2.2 Interaction with verbal coordination

(42) demonstrates an interesting issue arising when NCC (*to Mary on Wednesday and to Sue on Friday*) co-occurs with verbal coordination, which is also represented as a set:

(42) John [[gave a book] or [lent a record]] [[to Mary on Wednesday] and [to Sue on Friday]]. (Maxwell & Manning 1996: (43))

[13] Multiclausal structures also arise under gapping (Section 5.3), in some instances of coordination of different grammatical functions (Section 4.4) and when unlike category coordination is reanalysed as NCC (Section 3.1).

Strictly speaking, (42) is more complex than necessary to show the issue at hand:[14] *[[gave a book] or [lent a record]]* is another instance of NCC, which means that more complex c-structure rules are needed to handle this example. (43) is the "standard" VP rule which is split into partial VP rules in (44)–(48) in order to handle NCC in (42).

(43) $\begin{array}{lllll} \text{VP} \longrightarrow & \text{V} & \text{NP} & \text{PP} & \text{PP}^* \\ & & (\uparrow \textsc{obj}){=}\downarrow & (\uparrow \textsc{obl}){=}\downarrow & \downarrow{\in}(\uparrow \textsc{adj}) \end{array}$

(44) $\text{VP} \longrightarrow \text{VP-x} \quad \text{x-VP}$

(45) $\begin{array}{llll} \text{VP-x} \longrightarrow & \text{VP-x} & \text{Conj} & \text{VP-x} \\ & \downarrow{\in}\uparrow & & \downarrow{\in}\uparrow \end{array}$

(46) $\begin{array}{lll} \text{VP-x} \longrightarrow & \text{V} & \text{NP} \\ & & (\uparrow \textsc{obj}){=}\downarrow \end{array}$

(47) $\begin{array}{llll} \text{x-VP} \longrightarrow & \text{x-VP} & \text{Conj} & \text{x-VP} \\ & \downarrow{\in}\uparrow & & \downarrow{\in}\uparrow \end{array}$

(48) $\begin{array}{lll} \text{x-VP} \longrightarrow & \text{PP} & \text{PP}^* \\ & (\uparrow \textsc{obl}){=}\downarrow & \downarrow{\in}(\uparrow \textsc{adj}) \end{array}$

The procedural intuition of the analysis of (42) involves unifying two partial f-structures in the VP rule in (44), both of which happen to be sets: (49) corresponds to VP-x (*gave a book or lent a record*) built using the rules in (45)–(46), while (50) corresponds to x-VP (*to Mary on Wednesday and to Sue on Friday*) built using (47)–(48).

(49) $$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \textsc{pred} & \text{`give}\langle\textsc{subj},\boxed{2},\textsc{obl}\rangle\text{'} \\ \textsc{obj} & \boxed{2}\left[\textsc{pred}\ \text{`book'}\right] \end{array}\right], \left[\begin{array}{ll} \textsc{pred} & \text{`lend}\langle\textsc{subj},\boxed{3},\textsc{obl}\rangle\text{'} \\ \textsc{obj} & \boxed{3}\left[\textsc{pred}\ \text{`record'}\right] \end{array}\right] \right\} \\ \textsc{conj}\quad \textsc{or} \end{array}\right]$$

(50) $$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \textsc{obl} & \left[\textsc{pred}\ \text{`Mary'}\right] \\ \textsc{adj} & \left\{\left[\begin{array}{ll} \textsc{pred} & \text{`on}\langle\boxed{1}\rangle\text{'} \\ \textsc{obj} & \boxed{1}\left[\textsc{pred}\ \text{`Wed'}\right] \end{array}\right]\right\} \end{array}\right], \left[\begin{array}{ll} \textsc{obl} & \left[\textsc{pred}\ \text{`Sue'}\right] \\ \textsc{adj} & \left\{\left[\begin{array}{ll} \textsc{pred} & \text{`on}\langle\boxed{2}\rangle\text{'} \\ \textsc{obj} & \boxed{2}\left[\textsc{pred}\ \text{`Fri'}\right] \end{array}\right]\right\} \end{array}\right] \right\} \\ \textsc{conj}\quad \textsc{and} \end{array}\right]$$

[14]The same issue arises in a modified version of (24) with simple coordination of verbs (*gave or lent*):

(i) Fred [[gave] or [lent]] [[to Mary on Wednesday] and [to Scott on Friday]] his Dubé torches.

As discussed in Section 2.1, when a set is unified with a non-set f-structure, the non-set f-structure is distributed over the set. Maxwell & Manning (1996) discuss the issue of unifying two sets[15] on the basis of example (42), where the first set contains elements labelled as f_1 (*gave a book*) and f_2 (*lent a record*), see the f-structure in (49), while the second set contains f_3 (*to Mary on Wednesday*) and f_4 (*to Sue on Friday*), see (50).

Maxwell & Manning (1996) point out that a possible but undesired result of unifying (49) and (50) is set union, yielding an f-structure containing a set with 4 elements. This is schematically shown in (51), while the corresponding partial f-structure is given in (52).

(51) $\uparrow\{f_1,f_2,f_3,f_4\}$

(52)
$$\left[\begin{array}{l} \left\{\begin{array}{l} \left[\begin{array}{ll}\mathrm{PRED} & \text{‘GIVE⟨SUBJ,}\boxed{2}\text{,OBL⟩’}\\ \mathrm{OBJ} & \boxed{2}\left[\mathrm{PRED}\ \text{‘BOOK’}\right]\end{array}\right], \left[\begin{array}{ll}\mathrm{PRED} & \text{‘LEND⟨SUBJ,}\boxed{3}\text{,OBL⟩’}\\ \mathrm{OBJ} & \boxed{3}\left[\mathrm{PRED}\ \text{‘RECORD’}\right]\end{array}\right],\\ \left[\begin{array}{ll}\mathrm{OBL} & \left[\mathrm{PRED}\ \text{‘Mary’}\right]\\ \mathrm{ADJ} & \left\{\left[\begin{array}{ll}\mathrm{PRED} & \text{‘ON⟨}\boxed{4}\text{⟩’}\\ \mathrm{OBJ} & \boxed{4}\left[\mathrm{PRED}\ \text{‘Wed’}\right]\end{array}\right]\right\}\end{array}\right], \left[\begin{array}{ll}\mathrm{OBL} & \left[\mathrm{PRED}\ \text{‘Sue’}\right]\\ \mathrm{ADJ} & \left\{\left[\begin{array}{ll}\mathrm{PRED} & \text{‘ON⟨}\boxed{5}\text{⟩’}\\ \mathrm{OBJ} & \boxed{5}\left[\mathrm{PRED}\ \text{‘Fri’}\right]\end{array}\right]\right\}\end{array}\right] \end{array}\right\}\\ \mathrm{CONJ}\quad \mathrm{OR}\neq\mathrm{AND} \end{array}\right]$$

(52) is ill-formed for three reasons.[16] First, it is incomplete: f_1 and f_2 have a missing OBL(ique) argument. Secondly, it is incoherent: f_3 and f_4 have no PRED subcategorising for their OBL arguments. Finally, it is inconsistent due to conflicting values of the CONJ attribute: f_1 and f_2 are conjoined with *or* (($\uparrow$ CONJ) OR), while f_3 and f_4 are conjoined with *and* (($\uparrow$ CONJ)=AND). Unifying these f-descriptions results in a clash ($\neq$), see (52).

Maxwell & Manning (1996) explain that the desired result is to distribute one set over the other, which yields a set containing 2 elements, each of which also contains 2 elements. As explained below, there are two ways in which this can be done.

The result of distributing the first set (f_1, f_2) over the second (f_3, f_4) is schematically shown in (53). This yields the partial f-structure in (54), where the top-level conjunction is AND (it joins f_3 and f_4), while the conjunction in embedded sets is OR (it joins f_1 and f_2). The sentence in (55) provides a natural language intuition of the f-structure in (54) (with the subject added in brackets, since its contribution is not present in (54)).

[15] The issue of unifying two sets also surfaces in other coordination phenomena, including multi-clausal coordination of different grammatical functions (Section 4.4) and gapping (Section 5.3).

[16] These problems persist after the f-structure of the subject (*John*) is distributed over all set elements.

(53) $\uparrow\{f_3\{f_1',f_2'\},f_4\{f_1'',f_2''\}\}$

(54)
$$\left[\begin{array}{l}
\left\{\begin{array}{l}
\left[\begin{array}{l}
\left\{\left[\begin{array}{ll}
\text{PRED} & \text{`GIVE}\langle\text{SUBJ},\boxed{2},\boxed{3}\rangle\text{'}\\
\text{OBJ} & \boxed{2}\left[\text{PRED}\ \ \text{`BOOK'}\right]\\
\text{OBL} & \boxed{3}\left[\text{PRED}\ \ \text{`MARY'}\right]\\
\text{ADJ} & \left\{\boxed{4}\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{5}\rangle\text{'}\\ \text{OBJ} & \boxed{5}\left[\text{PRED}\ \ \text{`WED'}\right]\end{array}\right]\right\}
\end{array}\right],
\left[\begin{array}{ll}
\text{PRED} & \text{`LEND}\langle\text{SUBJ},\boxed{9},\boxed{3}\rangle\text{'}\\
\text{OBJ} & \boxed{9}\left[\text{PRED}\ \ \text{`RECORD'}\right]\\
\text{OBL} & \boxed{3}\\
\text{ADJ} & \{\boxed{4}\}
\end{array}\right]\right\}\\
\text{CONJ}\ \ \text{OR}
\end{array}\right],\\
\left[\begin{array}{l}
\left\{\left[\begin{array}{ll}
\text{PRED} & \text{`GIVE}\langle\text{SUBJ},\boxed{2},\boxed{6}\rangle\text{'}\\
\text{OBJ} & \boxed{2}\\
\text{OBL} & \boxed{6}\left[\text{PRED}\ \ \text{`SUE'}\right]\\
\text{ADJ} & \left\{\boxed{7}\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{8}\rangle\text{'}\\ \text{OBJ} & \boxed{8}\left[\text{PRED}\ \ \text{`FRI'}\right]\end{array}\right]\right\}
\end{array}\right],
\left[\begin{array}{ll}
\text{PRED} & \text{`LEND}\langle\text{SUBJ},\boxed{9},\boxed{6}\rangle\text{'}\\
\text{OBJ} & \boxed{9}\\
\text{OBL} & \boxed{6}\\
\text{ADJ} & \{\boxed{7}\}
\end{array}\right]\right\}\\
\text{CONJ}\ \ \text{OR}
\end{array}\right]
\end{array}\right\}\\
\text{CONJ}\ \ \text{AND}
\end{array}\right]$$

(55) (John) [[gave a book or lent a record] to Mary on Wednesday] and [[gave a book or lent a record] to Sue on Friday].

By contrast, (56) schematically shows the opposite situation, where the second set (f_3, f_4) is distributed over the first set (f_1, f_2). This yields the partial f-structure in (57), where the top-level conjunction is OR (it joins f_1 and f_2), while the conjunction in embedded sets is AND (it joins f_3 and f_4). (58) provides the natural language intuition of (57).

(56) $\uparrow\{f_1\{f_3',f_4'\},f_2\{f_3'',f_4''\}\}$

(57)
$$\left[\begin{array}{l}
\left\{\begin{array}{l}
\left[\begin{array}{l}
\left\{\left[\begin{array}{ll}
\text{PRED} & \text{`GIVE}\langle\text{SUBJ},\boxed{2},\boxed{3}\rangle\text{'}\\
\text{OBJ} & \boxed{2}\left[\text{PRED}\ \ \text{`BOOK'}\right]\\
\text{OBL} & \boxed{3}\left[\text{PRED}\ \ \text{`MARY'}\right]\\
\text{ADJ} & \left\{\boxed{4}\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{5}\rangle\text{'}\\ \text{OBJ} & \boxed{5}\left[\text{PRED}\ \ \text{`WED'}\right]\end{array}\right]\right\}
\end{array}\right],
\left[\begin{array}{ll}
\text{PRED} & \text{`GIVE}\langle\text{SUBJ},\boxed{2},\boxed{6}\rangle\text{'}\\
\text{OBJ} & \boxed{2}\\
\text{OBL} & \boxed{6}\left[\text{PRED}\ \ \text{`SUE'}\right]\\
\text{ADJ} & \left\{\boxed{7}\left[\begin{array}{ll}\text{PRED} & \text{`ON}\langle\boxed{8}\rangle\text{'}\\ \text{OBJ} & \boxed{8}\left[\text{PRED}\ \ \text{`FRI'}\right]\end{array}\right]\right\}
\end{array}\right]\right\}\\
\text{CONJ}\ \ \text{AND}
\end{array}\right],\\
\left[\begin{array}{l}
\left\{\left[\begin{array}{ll}
\text{PRED} & \text{`LEND}\langle\text{SUBJ},\boxed{9},\boxed{3}\rangle\text{'}\\
\text{OBJ} & \boxed{9}\left[\text{PRED}\ \ \text{`RECORD'}\right]\\
\text{OBL} & \boxed{3}\\
\text{ADJ} & \{\boxed{4}\}
\end{array}\right],
\left[\begin{array}{ll}
\text{PRED} & \text{`LEND}\langle\text{SUBJ},\boxed{9},\boxed{6}\rangle\text{'}\\
\text{OBJ} & \boxed{9}\\
\text{OBL} & \boxed{6}\\
\text{ADJ} & \{\boxed{7}\}
\end{array}\right]\right\}\\
\text{CONJ}\ \ \text{AND}
\end{array}\right]
\end{array}\right\}\\
\text{CONJ}\ \ \text{OR}
\end{array}\right]$$

(58) (John) [gave a book [to Mary on Wednesday and to Sue on Friday]] or [lent a record [to Mary on Wednesday and to Sue on Friday]].

As shown above, due to the fact that there are two ways of distributing one set over the other, (42) has two possible interpretations, depending on whether the scope of disjunction is narrow ((53)–(54)) or wide ((56)–(57)). While this may not be immediately obvious, there is a significant difference in truth conditions between these two interpretations.

In (54) where disjunction has narrow scope, each woman (Mary, Sue) is given a book or lent a record, while in (57) where disjunction has wide scope, both women (Mary and Sue) are given a book or lent a record. This is why (57) could be referred to as the symmetric reading – if Mary is given a book, Sue is also given a book (and vice versa); the same applies to being lent a record. By contrast, (54) does not require such symmetry: this reading is true when Mary (but not Sue) is given a book and Sue (but not Mary) is lent a record (or the other way round). While (54) is true in all situations when (57) is true, the opposite does not hold: there are scenarios when (54) is true but (57) is not.

While the grammar produces both solutions discussed above for (42), there are different views on which of these is more natural. As reported in Maxwell & Manning (1996: 13): "Blevins (1994) argues that the wide scope reading for the disjunction is the most natural interpretation, but we tend to think the opposite".

3 Coordination of unlike categories

While it has been claimed that coordination can only join identical categories (Chomsky (1957: 36), Williams (1981); more recently Bruening & Al Khalaf (2020)), many works have challenged such claims, showing that there is no such requirement (Peterson (1981), Sag et al. (1985), Bayer (1996); more recently Patejuk & Przepiórkowski (2023)).

When discussing unlike category coordination, the following examples are often used:

(59) Pat is [[a Republican] and [proud of it]]. (Sag et al. 1985: 117, (2b))

(60) Pat is [either [stupid] or [a liar]]. (Sag et al. 1985: 117, (2a))

(61) Pat has become [[a banker] and [very conservative]]. (Sag et al. 1985: 118, (3a))

(62) I consider John [[stupid] and [a fool]]. (Peterson 1981: (35))

(63) I consider that [[a rude remark] and [in very bad taste]]. (Sag et al. 1985: 118, (3b))

(64) We walked [[slowly] and [with great care]]. (Sag et al. 1985: 140, (57))

Except (64), which is an example of coordination of modifiers, all examples above involve predicative complements. Modifiers and predicative complements are the two most popular example types discussed in the literature on unlike category coordination.

There are also examples where unlike category coordination corresponds to a non-predicative argument. As discussed in Patejuk & Przepiórkowski (2023) on the basis of examples below, some predicates require an argument defined in terms of semantics rather than syntactic categories: expressing location (RESIDE), manner (TREAT), duration (LAST) etc. Such phrases may also act as modifiers: (64) is an example of a manner modifier.

(65) [[That place] and [behind these shops]] are where many families reside.

(66) Do you treat the four museums [[individually] or [as a collective]]?

(67) Immunity may last [[10 years] or [longer]]

There are also non-predicative arguments which are not defined semantically. (68) is a famous example often used in the context of unlike category coordination.

(68) You can depend on [[my assistant] and [that he will be on time]]. (Sag et al. 1985: 165, (124b))

However, (68) is controversial/problematic because it involves a subcategorisation violation. While the conjunct closer to the head obeys its subcategorisation requirements, (69), the other conjunct does not, see (70) – neither as a complement of the preposition ON, nor as a direct complement of the verb:

(69) You can depend on my assistant.

(70) *You can depend (on) that he will be on time.

Normally each conjunct is expected to satisfy the subcategorisation requirements of the verb it depends on – this is the case in two other famous examples from Sag et al. (1985):

(71) Pat remembered [[the appointment] and [that it was important to be on time]]. (Sag et al. 1985: 165, (123a))

(72) [[That Himmler appointed Heydrich] and [the implications thereof]] frightened many observers. (Sag et al. 1985: 165, (123b))

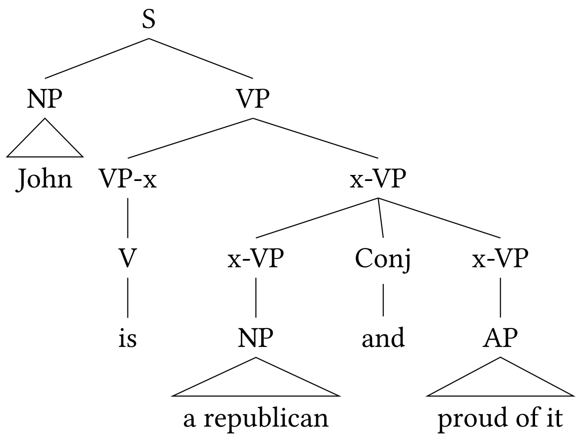
The rest of this section focuses on examples which satisfy this constraint, so it will not cover subcategorisation violations such as (68).

3.1 Unlike category coordination or ellipsis

One way to approach the phenomenon of unlike category coordination is to assume that ellipsis is involved, so that what is coordinated are not unlike categories, but larger categories of the same type: for instance two (or more) categories such as S, CP or VP – with ellipsis of the verb in one of the conjuncts (typically the second).

Maxwell & Manning (1996: 3) point out that the solution they propose for non-constituent coordination (NCC, discussed in Section 2) could be used to avoid unlike category coordination in examples such as *John is a republican and proud of it* by "coordinating partial VPs rather than attempting to coordinate an NP and an AP", see the structures in (73)–(74).[17]

(73)



(Maxwell & Manning 1996: (14))

(74)
$$\left[\begin{array}{l}\left\{\left[\begin{array}{ll}\text{PRED} & \text{`BE}\langle\boxed{2}\rangle\boxed{1}\text{'}\\ \text{SUBJ}\ \boxed{1} & [\text{PRED}\ \text{`JOHN'}]\\ \text{XCOMP}\ \boxed{2} & \left[\begin{array}{ll}\text{PRED} & \text{`REPUBLICAN}\langle\boxed{1}\rangle\text{'}\\ \text{SUBJ} & \boxed{1}\end{array}\right]\end{array}\right], \left[\begin{array}{ll}\text{PRED} & \text{`BE}\langle\boxed{3}\rangle\boxed{1}\text{'}\\ \text{SUBJ} & \boxed{1}\\ \text{XCOMP}\ \boxed{3} & \left[\begin{array}{ll}\text{PRED} & \text{`PROUD}\langle\boxed{1}\rangle\text{'}\\ \text{SUBJ} & \boxed{1}\end{array}\right]\end{array}\right]\right\}\\ \text{CONJ}\quad \text{AND}\end{array}\right]$$

[17] The contribution of *of it* is consistently omitted in the following f-structures.

As explained in Section 2, such an analysis produces multiclausal f-structures, as shown in (74).

While reanalysing unlike category coordination as same category coordination of larger categories seems to be a possibility sometimes, there are situations where it has undesired consequences such as having a different reading. As observed in Dalrymple (2017), examples with modifiers such as *simultaneously* and *alternately* have different readings depending on whether unlike category coordination is involved (see the bracketings in (75) and (77)), or an "ellipsis-based"[18] analysis is involved (compare (76) and (78), respectively):

(75) Fred is simultaneously [[a professor] and [ashamed of his work]]. (Dalrymple 2017: (16a))

(76) Fred [[is simultaneously a professor] and [~~is simultaneously~~ ashamed of his work]]. (Dalrymple 2017: (16b))

(77) Fred is alternately [[in a good mood] and [suicidal]]. (Dalrymple 2017: (17a))

(78) Fred [[is alternately in a good mood] and [~~is alternately~~ suicidal]]. (Dalrymple 2017: (17b))

In the case of *John is a republican and proud of it*, the truth conditions are the same no matter whether this string is analysed as coordination of unlike categories (giving rise to a monoclausal structure where the predicative complement corresponds to unlike category coordination of an NP and an AP, see (79)) or as same category coordination of VPs, as in (74), which is equivalent to multiclausal *John [[is a republican] and [~~is~~ proud of it]]*.

(79)
$$\left[\begin{array}{ll} \text{PRED} & \text{‘BE}\langle\boxed{2}\rangle\boxed{1}\text{’} \\ \text{SUBJ}\ \boxed{1} & \left[\text{PRED}\ \ \text{‘JOHN’}\right] \\ \text{XCOMP}\ \boxed{2} & \left[\begin{array}{l} \left\{ \left[\begin{array}{ll}\text{PRED} & \text{‘REPUBLICAN}\langle\boxed{1}\rangle\text{’} \\ \text{SUBJ} & \boxed{1}\end{array}\right], \left[\begin{array}{ll}\text{PRED} & \text{‘PROUD}\langle\boxed{1}\rangle\text{’} \\ \text{SUBJ} & \boxed{1}\end{array}\right] \right\} \\ \text{CONJ}\ \ \ \text{AND} \end{array}\right] \end{array}\right]$$

However, there is a clear difference when negation is involved. Consider the string *John is not a republican and proud of it*. Under the NCC reanalysis of unlike category coordination proposed in Maxwell & Manning (1996), this sentence involves a coordination of two negated VPs – this corresponds to (80) which involves a conjunction of two negated predicates, which is schematically shown in (81).

[18] This includes the NCC reanalysis proposed by Maxwell & Manning (1996).

(80) John [[is not a republican] and [~~is not~~ proud of it]].

(81) [¬A ∧ ¬B]

By contrast, under the analysis where genuine coordination of unlike categories is involved, as in (82), the semantics, schematically shown in (83), involves a negation of a conjunction – under De Morgan's laws, this is equivalent to a disjunction of negations.

(82) John is not [[a republican] and [proud of it]].

(83) ¬[A ∧ B] ≡ [¬A ∨ ¬B]

As a consequence, the two analyses of the string *John is not a republican and proud of it* have different meanings. Under the NCC analysis in (80), it can only mean (it has only one reading where it is true): John is not a republican, he is not proud of it ([¬A ∧ ¬B]). Apart from this reading, the following two readings are also available under the unlike category coordination analysis in (82): John is a republican, he is not proud of it ([A ∧ ¬B]); John is not a republican, he is proud of it ([¬A ∧ B]). Even though these two are possible readings of this string, they are not available under the NCC analysis.

An analogous issue arises in examples with modifiers such as (64). When negation is present (*We did not walk slowly and with great care*), different analyses also have different meanings. While NCC in (84) has the meaning in (81) which has only one reading (he did not walk slowly, he did not walk with great care), unlike category coordination in (85) has the meaning in (83) where two more readings are possible (he walked slowly, he did not walk with great care; he did not walk slowly, he walked with great care).

(84) We [[did not walk slowly] and [~~did not walk~~ with great care]].

(85) We did not walk [[slowly] and [with great care]].

As shown above, while some examples of unlike category coordination can be reanalysed as conjunction reduction without undesired side-effects (such as distorted, bad semantics), it is not the case that all instances of unlike category coordination can be reanalysed as conjunction reduction (using the analysis designed for NCC). Let us therefore proceed to the discussion of how genuine unlike category coordination can be handled in LFG.

3.2 Categories and c-structure labels

Once the false assumption that coordination can only join elements corresponding to the same category is rejected, the following question immediately arises:

when unlike categories are coordinated, what is the category of the coordinate phrase as a whole? Over time, there have been various answers to this question – these are discussed below.

Peterson (2004) proposed that the category of unlike category coordination is the same as the category of the first conjunct, as in the rule in (86):[19]

(86) $\begin{array}{lllll} \text{X} & \longrightarrow & \text{X} & \text{Conj} & \text{X} \\ & & {\downarrow}{\in}{\uparrow} & & {\downarrow}{\in}{\uparrow} \end{array}$ (Peterson 2004: (20))

As pointed out in Dalrymple (2017: 38): "This analysis makes the incorrect prediction that the distribution of an unlike category coordination structure matches the distribution of the category of the first conjunct."[20]

While Peterson (2004) makes unlike category coordination endocentric in the sense that the topmost category is the same as one of the conjuncts, Patejuk (2015) proposed to use a special category for unlike category coordination (XP or UP), making it exocentric: the rule in (87) uses YP and ZP as variables for different categories.

(87) $\begin{array}{lllll} \text{XP} & \longrightarrow & \text{YP} & \text{Conj} & \text{ZP} \\ & & {\downarrow}{\in}{\uparrow} & & {\downarrow}{\in}{\uparrow} \end{array}$ (Patejuk 2015: (4.8))

This proposal is complemented by the use of the distributive CAT attribute in f-structure, making it possible to impose category constraints at this level of representation – rather than using CAT predicate (see Section 3.5.1) and c-structure labels. Under the analysis of Patejuk (2015), the f-structure in (88) corresponds to *John is a republican and proud (of it)*.

(88)
$$\left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{be}\langle\boxed{2}\rangle\boxed{1}\text{'} \\ \textsc{subj}\ \boxed{1} & \left[\textsc{pred}\ \ \text{`}\textsc{John}\text{'}\right] \\ \textsc{xcomp}\ \boxed{2} & \left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{republican}\langle\boxed{1}\rangle\text{'} \\ \textsc{subj} & \boxed{1} \\ \textsc{cat} & \textsc{n} \end{array}\right], \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{proud}\langle\boxed{1}\rangle\text{'} \\ \textsc{subj} & \boxed{1} \\ \textsc{cat} & \textsc{adj} \end{array}\right] \right\} \\ \textsc{conj}\ \ \textsc{and} \end{array}\right] \end{array}\right]$$

[19]While Peterson (2004) uses the C category for the conjunction, it was replaced with Conj in (86) for the sake of consistency as well as to avoid potential confusion (C is typically used for complementisers).

[20]As noted in Bruening & Al Khalaf (2020), Peterson (2004) focuses on cases where the coordinate phrase follows the selector, so the first conjunct is closest to the selector. However, there are cases where coordination precedes the selector (see (72)), so the first conjunct would be farthest from the selector (rather than closest). While this issue can be resolved by assuming that it is the conjunct closest to the selector that corresponds to the topmost category, the point made in Dalrymple (2017) would still hold.

Dalrymple (2017: 38) provides a critique of this approach, focusing on c-structure labels: "the proposal does not allow the possibility of imposing the category requirements that were shown to be necessary [...], since on this view all unlike category coordinations have the same category. It also makes it difficult to enforce category-function correlations and to control the distribution of phrases of different categories, since there is no relation between the category of the unlike category coordination structure and the categories of the conjuncts." This criticism only holds as far as c-structure is concerned (so when the CAT predicate is used, which operates on c-structure labels; see Section 3.5.1). Under the proposal of Patejuk (2015), the categorial constraints discussed in Dalrymple (2017) are imposed at the level of f-structure using the CAT attribute. As shown in (88), conjuncts corresponding to the XCOMP grammatical function have different categories: the value of CAT is N for the noun *republican* and ADJ for the adjective *proud*.

Dalrymple (2017) offers a novel, feature-based solution for choosing the c-structure label of unlike category coordination. While it is conceptually similar to the proposal of Sag et al. (1985), it does not involve controversial feature decomposition (see Bayer (1996) for an extensive critique) as features directly correspond to basic syntactic categories, see (89):

(89) (Dalrymple 2017: (43))

Abbreviation	Feature matrix
N	[N +, V −, P −, ADJ −, ADV −]
V	[N −, V +, P −, ADJ −, ADV −]
P	[N −, V −, P +, ADJ −, ADV −]
Adj	[N −, V −, P −, ADJ +, ADV −]
Adv	[N −, V −, P −, ADJ −, ADV +]

These feature matrices correspond to lexical categories. The category of a coordinate phrase is resolved in a different way (Dalrymple 2017: 48): "the category of a coordinate phrase has the value + for a category feature if there is some conjunct with the value + for that feature". This makes it possible to provide a simple, elegant account of unlike category coordination: the c-structure in (90) corresponds to *a Republican and proud of it*, where the label of unlike category coordination is [N +, ADJ +].

(90)

[N +, ADJ +]

[N +, V −, P −, ADJ −, ADV −] *and* [N −, V −, P −, ADJ +, ADV −]

a Republican proud of it

(Przepiórkowski & Patejuk 2021: (5))

However, as noted in Przepiórkowski & Patejuk (2021: 208, fn. 4), under such an analysis of coordination, same category coordination has a different category than its conjuncts. For instance, in the case of NP coordination, while the category of all NP conjuncts is [N +, V −, P −, ADJ −, ADV −], the category of the coordinate NP is [N +].

Also, Dalrymple (2017) does not discuss how functional categories such as CP (complementizer phrase) or InfP (infinitival phrase) would be distinguished under this account, which is relevant for unlike category coordination (such as CP and NP, CP and PP, etc.).

Przepiórkowski & Patejuk (2021) offer an alternative solution to the problem of the category of coordination of unlike categories. The analysis proposed in Dalrymple (2017) is limited to categories, while some instances of unlike category coordination require additional constraints, such as appropriate case, complementizer or preposition form (see Section 3.5.2). As a consequence, in order to account for unlike category coordination, it is not enough to state categorial constraints using the built-in CAT predicate (see Section 3.5.1). Przepiórkowski & Patejuk (2021) propose to remove c-structure labels altogether (which is formally equivalent to having just one label) and instead use CAT attribute in f-structure for imposing categorial restrictions (as in Patejuk (2015)). As an example, Przepiórkowski & Patejuk (2021) propose the rule in (91) as a replacement for the rule in (92):

(91) $$\bullet \longrightarrow \begin{array}{c} \bullet \\ (\downarrow \text{CAT}) =_c \text{P} \\ \uparrow=\downarrow \end{array} \quad \begin{array}{c} \bullet \\ (\downarrow\text{CAT}) \in_c \{\text{P}, \text{N}\} \\ (\uparrow \text{OBJ})=\downarrow \end{array}$$
(Przepiórkowski & Patejuk 2021: (35))

(92) $$\text{P}' \longrightarrow \begin{array}{c} \text{P} \\ \uparrow=\downarrow \end{array} \quad \begin{array}{c} \{\text{NP}|\text{PP}\} \\ (\uparrow \text{OBJ})=\downarrow \end{array}$$
(Przepiórkowski & Patejuk 2021: (32))

Under this proposal, as in Patejuk (2015), all constraints (related to categories and other features such as case, complementizer or preposition form, etc.) are imposed in f-structure.[21] However, unlike in Patejuk (2015), there is no need for arbitrary c-structure labels for unlike category coordination (such as XP or UP), which was criticised in Dalrymple (2017).

Summing up, this subsection presented different approaches to the problem of choosing the topmost category corresponding to coordination of unlike categories.

[21] While Patejuk (2015) uses complex off-path constraints to formalise disjunctive constraints, Przepiórkowski & Patejuk (2021) propose to reuse the local variable notation, which results in simpler and more readable constraints – see the discussion in Section 3.5.2.

3.3 Categories and grammatical functions

Since imposing constraints in f-descriptions relies on grammatical functions to identify the element to be constrained, there is the key question of which grammatical function is appropriate when coordinating unlike categories.

Answering this question can be non-trivial, partially because the choice of the appropriate grammatical function can be controversial even outside of coordination. While LFG considers grammatical functions as primitives of the theory, independent of the position in the c-structure and/or the c-structure category, there has been some discussion and controversy concerning certain grammatical functions. See Belyaev forthcoming [this volume] for discussion and references.

Probably the least controversial (though not uncontroversial) grammatical functions include the SUBJ(ect) and the OBJ(ect). Still, there are different definitions of OBJ: some (e.g. Patejuk (2015)) choose to define it as the grammatical function which changes to SUBJ when undergoing passivisation, while others (e.g. Börjars & Vincent (2008)) do not consider this as a necessary characteristic.

There has been a lot of debate about complement clauses. Dalrymple & Lødrup (2000) argue that different grammatical functions may be appropriate for complement clauses in different languages, considering OBJ(ect) and COMP ((non-object) closed clausal complement) and proposing criteria for distinguishing these. By contrast, Alsina et al. (2005) argue for getting rid of COMP and using OBL(ique) instead for non-object complement clauses (among other argument types). Furthermore, Alsina et al. (2005) suggest that it should also be possible to get rid of XCOMP (open clausal complement).

On the basis of data from Polish and English, Patejuk & Przepiórkowski (2014a) argue that using XCOMP for open (controlled) clausal complements can be problematic, because it is possible to coordinate infinitival phrases (open, controlled) with non-predicative nominals which are closed (do not require control):

(93) Polish
Chcę [[pić] i [papierosa]].
want drink.INF and cigarette.ACC
'I want to drink and a cigarette.' (Patejuk & Przepiórkowski 2014a: (1))

(94) My uncle said to hell with that and taught me [[karate], and [to fire weapons]]. (Patejuk & Przepiórkowski 2014a: (27))

Patejuk & Przepiórkowski (2014a) argue that such examples provide independent motivation to get rid of the XCOMP: while it would be suitable for the controlled infinitival conjunct (its subject is structure-shared with the matrix subject), it is not suitable for the nominal conjunct which is not controlled and does not have a subject.

Patejuk & Przepiórkowski (2014a) propose an analysis in terms of unlike category coordination, choosing OBJ as the grammatical function corresponding to coordination in (93).[22] An important novel feature of this analysis is making it possible to establish control into selected conjuncts. This is achieved using the CONTROLLER attribute (see Section 3.5.2 for detailed discussion), as shown in (95)[23] which corresponds to (93).

(95)
$$\left[\begin{array}{ll} \text{PRED} & \text{`WANT}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED}\ \ \text{`I'}\right] \\ \text{OBJ} & \boxed{2}\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{PRED} & \text{`DRINK}\langle\boxed{1}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \\ \text{CONTROLLER} & \boxed{1}\end{array}\right], \left[\begin{array}{ll}\text{PRED} & \text{`CIGARETTE'} \\ \text{CASE} & \text{ACC} \\ \text{CONTROLLER} & \boxed{1}\end{array}\right]\right\} \\ \text{CONJ}\ \ \ \text{AND}\end{array}\right]\end{array}\right]$$

(Patejuk & Przepiórkowski 2014a: (26))

Building on the proposals of Alsina et al. (2005) and Patejuk & Przepiórkowski (2014a), Patejuk & Przepiórkowski (2016) reexamine the repertoire of grammatical functions in LFG, providing additional arguments for getting rid of COMP and XCOMP. They show that it is possible to coordinate categories that would normally correspond to open and closed complements (which again leads to the issue of control into selected conjuncts).

While Patejuk & Przepiórkowski (2016) focus on the discussion of arguments, an analogous observation can be made with respect to adjuncts, where a similar distinction is often made, splitting adjuncts into closed, not controlled (ADJ) and open, controlled (XADJ). In the Polish examples in (96)–(98), the first conjunct would normally be classified as closed (ADJ), while the second conjunct would be open (XADJ). To account for such coordination, a common grammatical function should be identified for such dependents:[24]

(96) Polish
Wychodziliśmy [[szybko] i [unikając spojrzeń innych]].
left.1.PL.M1 quickly and avoiding gazes others
'We were leaving quickly and avoiding peoples' gazes.'

[22] If the ability to be passivised is a defining feature of OBJ, this argument should be an OBL in Polish.

[23] The CONJ attribute was added to this f-structure.

[24] In Polish, the verb agrees with its subject (which may be implicit, as in (96)–(98)), while predicative adjectives agree with their controller (which may also be implicit, as in (97)–(98)).

(97) Polish
Przyjechaliśmy do Kotoru [[dosyć późno] i [głodni jak
returned.1.PL.M1 to Kotor pretty late and hungry.NOM.PL.M1 like
wilki]]…
wolves
'We returned to Kotor pretty late and hungry as wolves…' (Google)

(98) Polish
Gdy [[niechętnie] i [zażenowany]] wchodził za
when reluctantly and embarrassed.NOM.SG.M1 entered.3.SG.M1 after
Nirą…
Nira
'When, reluctantly and hungry, he entered following Nira…' (NKJP)[25]

This observation is consistent with the general proposal of Patejuk & Przepiórkowski (2016: 549) who conclude that the repertoire of grammatical functions in LFG could be limited to just three: SUBJ(ect), OBJ(ect) (defined as the item that can undergo passivisation) and OBL(ique) which serves as the elsewhere grammatical function: "All other dependents, including adjuncts, may be called OBLiques, as in Alsina (1996)." Control into selected conjuncts of OBLiques would be handled in the same way as in (95).

Kaplan (2017) proposes that examples such as (99), analysed as unlike category coordination in Patejuk & Przepiórkowski (2016), see the f-structure in (100), could instead be analysed as non-constituent coordination (NCC, Maxwell & Manning (1996); see Section 2 and Section 3.1), compare the f-structure in (101).[26]

(99) The majority want [[peace] and [to live a comfortable life]]. (Patejuk & Przepiórkowski 2016: (9))

(100)
$$\left[\begin{array}{ll} \text{PRED} & \text{`WANT}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED `MAJORITY'}\right] \\ \text{OBJ} & \boxed{2}\left[\begin{array}{l} \left\{ \left[\begin{array}{ll}\text{PRED} & \text{`PEACE'}\\ \text{CONTROLLER} & \boxed{1}\end{array}\right], \left[\begin{array}{ll}\text{PRED} & \text{`LIVE}\langle\boxed{1},\boxed{3}\rangle\text{'}\\ \text{SUBJ} & \boxed{1}\\ \text{OBJ} & \boxed{3}\left[\text{PRED `LIFE'}\right]\\ \text{CONTROLLER} & \boxed{1}\end{array}\right]\right\} \\ \text{CONJ} \quad \text{AND}\end{array}\right]\end{array}\right]$$

[25]NKJP is the National Corpus of Polish (Przepiórkowski et al. (2011, 2012); http://nkjp.pl).
[26]The contribution of *comfortable* is ignored in (100)–(101).

(101)

$$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{PRED} & \text{‘WANT}\langle\boxed{1},\boxed{2}\rangle\text{’} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED ‘MAJORITY’}\right] \\ \text{OBJ} & \boxed{2}\left[\text{PRED ‘PEACE’}\right]\end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{‘WANT}\langle\boxed{1},\boxed{3}\rangle\text{’} \\ \text{SUBJ} & \boxed{1} \\ \text{XCOMP} & \boxed{3}\left[\begin{array}{ll}\text{PRED} & \text{‘LIVE}\langle\boxed{1},\boxed{4}\rangle\text{’} \\ \text{SUBJ} & \boxed{1} \\ \text{OBJ} & \boxed{4}\left[\text{PRED ‘LIFE’}\right]\end{array}\right]\end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND} \end{array}\right]$$

(Kaplan 2017: (29))

While (100) involves one instance of the predicate WANT with a coordinate object, the NCC strategy in (101) involves coordination of identical larger categories (VPs), which results in a multiclausal analysis: there are two instances of the predicate WANT, each with a different non-coordinate complement (OBJ vs. XCOMP).

Kaplan (2017: 138) explains that normally the lexical entry in (102) cannot give rise to the f-structure in (101) because "Disjunction in LFG normally has wide scope. Thus either the OBJ frame or the XCOMP frame would be distributed to both elements of the coordination set, and in each case one of the elements will fail the completeness/coherence tests."

(102) *want* $(\uparrow \text{PRED})=\text{‘WANT}\langle\text{SUBJ,OBJ}\rangle\text{’}$ (Kaplan 2017: (24))
$\vee\ [(\uparrow \text{PRED})=\text{‘WANT}\langle\text{SUBJ,XCOMP}\rangle\text{’}$
$(\uparrow \text{XCOMP SUBJ})=(\uparrow \text{SUBJ})]$

Kaplan (2017) offers two solutions to this problem. The first is to use the lexical entry in (103) which uses functional uncertainty for grammatical functions (OBJ or XCOMP) plus an off-path constraint attached to XCOMP establishing the subject control relation:

(103) *want* $(\uparrow \text{PRED})=\text{‘WANT}\langle\text{SUBJ,}\{\text{OBJ} \mid \underset{(\to\ \text{SUBJ})=(\leftarrow\ \text{SUBJ})}{\text{XCOMP}}\}\rangle\text{’}$

(Kaplan 2017: (28))

There are two potential challenges for (103): it uses functional uncertainty constructively (disjunction over grammatical functions in PRED) and it uses off-path constraints constructively (introducing a defining control equation). However, as mentioned in Patejuk & Przepiórkowski (2014a), while off-path constraints are non-constructive in XLE (Crouch et al. 2011), the native platform for implementing LFG grammars, this does not need to be the case in theoretical analyses (they point out that drafts of the following works allow constructive off-path constraints: Bresnan et al. (2016), Dalrymple et al. (2019)).

The second solution proposed by Kaplan (2017: 138, fn. 9) is to introduce a new built-in template, DISTRIB (see the discussion of (134) in Section 3.5.2), which makes it possible to "declare the disjunctive entry for *want* [(102)] as a narrow-scope distributive property".

Both solutions proposed in Kaplan (2017) make it possible to reanalyse simple cases of unlike category coordination as NCC (building on Maxwell & Manning (1996)), though without the requirement of strict identity of grammatical functions (due to the possibility of using different lexical entries for different conjuncts).

However, these solutions suffer from the same problems as NCC: they cannot handle more complex cases of unlikes (involving negation or modifiers, see the discussion in Section 3.1). There are no such issues with the analysis assuming unlike category coordination.

3.4 Coordinating predicative complements with participles

In early LFG work (Bresnan 1982, Kaplan & Bresnan 1982) the auxiliary BE is analysed as a raising verb. The f-structure in (104)[27] corresponds to the sentence *The elephant was worshipped by the child*, which involves passive voice: BE is the main verb (having a PRED attribute, with BE as its value), taking a raised subject and a verbal complement (VCOMP) corresponding to the passive lexical verb.

(104)
$$\left[\begin{array}{ll} \text{PRED} & \text{`BE}\langle\boxed{2}\rangle\boxed{1}\text{'} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED `ELEPHANT'}\right] \\ \text{VCOMP} & \boxed{2}\left[\begin{array}{ll} \text{PRED} & \text{`WORSHIP}\langle\boxed{1},\boxed{3}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \\ \text{OBL}_{\text{AG}} & \boxed{3}\left[\text{PRED `CHILD'}\right] \end{array}\right] \\ \text{TENSE} & \text{PAST} \end{array}\right]$$

(Bresnan 1982: Figure 1.4b)

The early LFG analysis of progressive constructions is very similar. Kaplan & Bresnan (1982) analyse the sentence *A girl is handing the baby a toy* using the lexical entries for the present participle *handing* and the auxiliary *is* in (105)–(106). These would give rise to the (simplified) f-structure in (107) where the auxiliary is the main verb (note that its PRED value is PROG, unlike in the passive (104)), taking a raised subject and a verbal complement (VCOMP) corresponding to the lexical verb.

(105) *handing* V (↑ PRED)='HAND⟨(↑ SUBJ)(↑ OBJ2)(↑ OBJ)⟩'
(↑ PARTICIPLE)=PRESENT

[27]Two errors in the original f-structure (Joan Bresnan, pc) were corrected in (104) by adding: the non-semantic SUBJ in the PRED of BE; structure-sharing of the SUBJ of BE and the SUBJ of WORSHIP.

(Kaplan & Bresnan 1982: (65))

(106) *is* V (↑ PRED)=‘PROG⟨(↑ VCOMP)⟩’
(↑ VCOMP PARTICIPLE)=$_c$ PRESENT
(↑ VCOMP SUBJ)=(↑ SUBJ)
(↑ SUBJ NUM)=SG

(Kaplan & Bresnan 1982: (70))

(107)
$$\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{prog}\langle\boxed{2}\rangle\boxed{1}\text{’} \\ \textsc{subj} & \boxed{1}\left[\textsc{pred}\ \text{‘}\textsc{girl}\text{’}\right] \\ \textsc{vcomp} & \boxed{2}\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{hand}\langle\boxed{1},\boxed{3},\boxed{4}\rangle\text{’} \\ \textsc{subj} & \boxed{1} \\ \textsc{obj} & \boxed{3}\left[\textsc{pred}\ \text{‘}\textsc{baby}\text{’}\right] \\ \textsc{obj}2 & \boxed{4}\left[\textsc{pred}\ \text{‘}\textsc{toy}\text{’}\right] \\ \textsc{participle} & \textsc{present} \end{array}\right] \end{array}\right]$$

Later, the standard LFG analysis of passive/progressive constructions has been to treat the lexical verb as the main verb, while the auxiliary only contributes a bundle of features (such as agreement features, tense, aspect, etc.) – it does not have its own PRED attribute. This results in a “flat” analysis (without embedding) of such constructions: (108) is the flat, monoclausal counterpart of (104), while (109) corresponds to (107).[28]

(108)
$$\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{worship}\langle\boxed{1},\boxed{2}\rangle \\ \textsc{subj} & \boxed{1}\left[\textsc{pred}\ \text{‘}\textsc{elephant}\text{’}\right] \\ \textsc{obl}_{\textsc{ag}} & \boxed{2}\left[\textsc{pred}\ \text{‘}\textsc{child}\text{’}\right] \\ \textsc{tense} & \textsc{past} \\ \textsc{passive} & + \end{array}\right]$$

(109)
$$\left[\begin{array}{ll} \textsc{pred} & \text{‘}\textsc{hand}\langle\boxed{1},\boxed{2},\boxed{3}\rangle \\ \textsc{subj} & \boxed{1}\left[\textsc{pred}\ \text{‘}\textsc{girl}\text{’}\right] \\ \textsc{obj} & \boxed{2}\left[\textsc{pred}\ \text{‘}\textsc{baby}\text{’}\right] \\ \textsc{obj}_\theta & \boxed{3}\left[\textsc{pred}\ \text{‘}\textsc{toy}\text{’}\right] \\ \textsc{tense} & \textsc{present} \\ \textsc{aspect} & \textsc{prog} \end{array}\right]$$

With predicative complements, the copula has been analysed over time as a raising verb – taking a subject and a predicative complement: open (XCOMP)[29] or

[28]Instead of OBJ2 used in early works for the secondary object, as in (107), (109) uses OBJ$_\theta$.

[29]While XCOMP is category neutral, in early LFG (Bresnan 1982, Kaplan & Bresnan 1982) different grammatical functions were used for different categories: ACOMP for adjectives, NCOMP for nouns, etc.

closed (PREDLINK), depending on the analysis. There have also been analyses where the predicative item is the main predicate, while the copula only contributes certain features (having no PRED). See Dalrymple et al. (2004) for a comprehensive discussion of all the possibilities.

There is an interesting interaction between unlike category coordination and constructions with an auxiliary (such as passive/progressive constructions). As discussed in Peterson (1981, 2004), it is possible to coordinate a predicative complement with a present/passive participle, see (110)–(115). In order to avoid having to analyse such examples as an instance of ellipsis (conjunction reduction resulting in a multiclausal structure),[30] it is necessary to adopt a uniform analysis of the linking word (as the main verb or not).

In English, many examples of unlike category coordination of a predicative complement and a present participle are discussed in Peterson (1981). Using examples such as (112), among others, Peterson (1981) argues that these are not instances of ellipsis (conjunction reduction) but genuine coordination of unlike categories:

(110) The children were [[happy] and [smiling]]. (Peterson 1981: (9))

(111) John is [[awake] and [asking for you]]. (Peterson 1981: (10))

(112) He was [both [happy] and [smiling]]. (Peterson 1981: (27))

Peterson (2004) provides more examples, including one with a passive participle, (114):

(113) Bill could be [[a plumber] and [making a fortune]]. (Peterson 2004: (8c))

(114) I imagined John [[a convicted felon] and [imprisoned for life]]. (Peterson 2004: (8g))

(115) The children are [[awake] and [asking for you]]. (Peterson 2004: (45))

Peterson (2004) provides the f-structure in (116) as the representation of (115):

(116)
$$\left[\begin{array}{ll} \mathrm{PRED} & \text{‘}\mathrm{BE}\langle\boxed{2}\rangle\boxed{1}\text{’} \\ \mathrm{SUBJ}\ \boxed{1} & \left[\mathrm{PRED}\ \ \text{‘}\mathrm{CHILDREN}\text{’}\right] \\ \mathrm{XCOMP}\ \boxed{2} & \left[\begin{array}{l} \left\{ \left[\begin{array}{ll}\mathrm{PRED} & \text{‘}\mathrm{AWAKE}\langle\boxed{1}\rangle\text{’}\\ \mathrm{SUBJ} & \boxed{1}\end{array}\right], \left[\begin{array}{ll} \mathrm{PRED} & \text{‘}\mathrm{ASK}\langle\boxed{1},\boxed{3}\rangle\text{’} \\ \mathrm{SUBJ} & \boxed{1} \\ \mathrm{OBL}_{\mathrm{GOAL}} & \boxed{3}\left[\mathrm{PRED}\ \ \text{‘}\mathrm{YOU}\text{’}\right]\end{array}\right]\right\} \\ \mathrm{CONJ}\ \ \ \mathrm{AND}\end{array}\right] \\ \mathrm{TENSE} & \mathrm{PRES}\end{array}\right]$$

[30]This is also the case under the proposal of Kaplan (2017) to introduce the DISTRIB template, making it possible to treat disjunctive lexical entries as narrow-scope distributive properties (see (134) in Section 3.5.2).

(Peterson 2004: (47))

While Peterson (2004) does not discuss the possibility of using the NCC analysis of Maxwell & Manning (1996) for unlike category coordination, it seems clear that he would not want to adopt it, because it results in a multiclausal f-structure representation, equivalent to VP-level coordination – an elliptical analysis that Peterson (2004) explicitly argues against.

Patejuk & Przepiórkowski (2014b) discuss similar data from Polish, focusing on the coordination of adjectives and passive participles such as in (117), where the first conjunct (*zrobiony* 'made') is a passive participle, the second (*bezpieczny* 'safe') is an adjective and the third (*zarejestrowany* 'registered') is a passive participle with a *by*-phrase:

(117) Polish

Nasz	pas	jest	[[dobrze	zrobiony],	[bezpieczny]
our	runway.NOM.SG.M3	is	well	made.NOM.SG.M3	safe.NOM.SG.M3

i	[zarejestrowany	przez	Urząd	Lotnictwa	Cywilnego]].
and	registered.NOM.SG.M3	by	Office.ACC	Aviation.GEN	Civil.GEN

'Our runway is well made, safe and registered by the Civil Aviation Office.'

(Patejuk & Przepiórkowski 2014b: (1))

Using Polish negation data as independent evidence, Patejuk & Przepiórkowski (2014b) argue for a unified treatment of BYĆ 'be' as a raising verb taking a complement which can be an adjective, a passive participle, or a coordination of these – as in (117), which they analyse as (118). As a result, as in Peterson (2004), passive and predicative constructions use the embedded representation (as opposed to the flat representation using co-heads).

(118)

$$\left[\begin{array}{ll} \text{PRED} & \text{`BE}\langle\boxed{2}\rangle\boxed{1}\text{'} \\ \text{SUBJ}\ \boxed{1} & \left[\text{PRED `RUNWAY'}\right] \\ \text{XCOMP}\ \boxed{2} & \left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{PRED} & \text{`MAKE}\langle\boxed{1}\rangle \\ \text{SUBJ} & \boxed{1} \\ \text{ADJ} & \left\{\left[\text{PRED `WELL'}\right]\right\} \\ \text{PASSIVE} & + \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`SAFE}\langle\boxed{1}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`REGISTER}\langle\boxed{1},\boxed{3}\rangle \\ \text{SUBJ} & \boxed{1} \\ \text{OBL}_{\text{AG}} & \boxed{3}\left[\text{PRED `CAO'}\right] \\ \text{PASSIVE} & + \end{array}\right] \right\} \\ \text{CONJ}\quad \text{AND} \end{array}\right] \end{array}\right]$$

(Patejuk & Przepiórkowski 2014b: (53))

3.5 Disjunctive constraints

The main remaining question related to unlike category coordination is how to impose disjunctive constraints (such as subcategorisation in examples discussed earlier). Over time, there have been two main approaches to this issue. They may also be used together.

3.5.1 CAT predicate

The first approach focuses on constraints related to c-structure categories, relying on the built-in CAT predicate for imposing such constraints, as defined in (119):

(119) CAT(f, C) iff $\exists n \in \phi^{-1}(f) : \lambda(n) \in C$

"CAT(f, C) is true if and only if there is some node n that corresponds to f via the inverse ϕ correspondence (ϕ^{-1}) whose label (λ) is in the set of categories C." (Dalrymple (2017: (24)) after Kaplan & Maxwell (1996: 93))

Dalrymple (2017) shows how CAT can be used to account for disjunctive subcategorisation requirements of the verb BECOME: assuming that CAT is distributive, each conjunct must satisfy the constraint imposed by CAT. As a result, (120) ensures that the predicative complement (PREDLINK or XCOMP, depending on the analysis) of BECOME must be an adjectival phrase (AdjP), a nominal phrase (NP), or a coordination of these, as in (121).

(120) CAT((↑ PREDLINK), {AdjP, NP}) (Dalrymple 2017: (26))

(121) Fred became [[a professor] and [proud of his work]]. (Dalrymple 2017: (6a))

The CAT predicate is designed specifically for imposing constraints on c-structure categories. However, as discussed earlier, accounting for unlike category coordination may require additional constraints, such as having a certain value of case, preposition or complementiser form, etc., or introducing control equations (see (93)–(94)).

Technically, features such as case, preposition form and complementiser form can be added to c-structure category labels, resulting in complex categories such as NP[case], PP[pform,case] or CP[compform], making it possible to impose extra constraints using the CAT predicate that is normally used only for category labels. However, there are some issues with such a solution. First, it requires copying f-structure information to c-structure, resulting in redundancy. More importantly, such a solution would not be sufficient for more complex phenomena such as structural case assignment to the object in Polish because its value of case depends on the presence or absence of negation on the verb assigning case. Simplifying, in Polish the structural object is accusative without negation, but it is genitive if negation is present. This requires more complex constraints.

Consider again the example in (93) (with the corresponding f-structure in (95)), where the object involves unlike category coordination. While the first conjunct (*pić* 'drink') is a controlled infinitival phrase (InfP), the second conjunct (*papierosa* 'cigarette') is an NP bearing accusative case (as structural case when there is no sentential negation). The simple CAT constraint in (122) restricts categories corresponding to the object of the verb CHCIEĆ 'want' to InfP or NP. The version using complex categories in (123) additionally restricts the case of the NP to accusative or genitive (the two possible values, as above).

(122) CAT((↑ OBJ), {InfP, NP})

(123) CAT((↑ OBJ), {InfP, NP[acc], NP[gen]})

While (122) does not restrict the value of case of the NP object in any way, (123) restricts it to accusative or genitive, but the crucial constraint making the value of case dependent on sentential negation is absent. Even with complex categories, it is not sufficient to use the CAT predicate to express more complex constraints necessary in unlike category coordination (such constraints are discussed in Section 3.5.2).

Dalrymple (2017) offers a novel solution to the issue of the category of unlike category coordination by replacing atomic c-structure labels (such as NP, AdjP, PP) with labels consisting of attribute-value structures (see Section 3.2). However, as discussed in Przepiórkowski & Patejuk (2021), such a solution would also not be able to handle more complex disjunctive subcategorisation requirements needed to account for unlike category coordination.

As an alternative, Przepiórkowski & Patejuk (2021) propose to remove category labels from c-structure and move category information to f-structure (see Section 3.2), so that all necessary constraints can be imposed at one level of representation: f-structure. This is discussed in more detail in Section 3.5.2.

3.5.2 F-structure constraints

The second type of disjunctive constraints is related to f-structure. In order to account for unlike category coordination, where each conjunct may satisfy a different set of constraints, such disjunctive constraints must be interpreted distributively, so that the disjunction is evaluated separately for each conjunct.

Consider (124): the object of UNDERSTAND involves unlike category coordination – its first conjunct is an NP, while the second conjunct is a CP with the complementizer THAT:

(124) I understand [[those concerns] and [that they are sincerely held]].
(Patejuk & Przepiórkowski 2023: (39))

Intuitively, the constraint in (125) should be appropriate to account for (124):

(125) $[(\uparrow \text{OBJ CASE}) =_c \text{ACC} \lor (\uparrow \text{OBJ COMP-FORM}) =_c \text{THAT}]$

However, as observed in Przepiórkowski & Patejuk (2012) when discussing structural case assignment to Polish subjects which also involves disjunction,[31] while the intended effect of such a disjunctive constraint is for it to be evaluated independently for each conjunct, so that different conjuncts may have different specifications, the actual effect is exactly the opposite: the disjunctive constraint is evaluated once (one disjunct is chosen) and the result is distributed to all conjuncts – as a consequence, all conjuncts must have the same specification. The following formulae from Patejuk (2015) formalise this contrast:

(126) a. $\forall x \in (\uparrow \text{GF})[A(x) \lor B(x)]$ (intended)

b. $\forall x \in (\uparrow \text{GF})\, A(x) \lor \forall x \in (\uparrow \text{GF})\, B(x)$ (actual)

The "liberal" solution offered in Przepiórkowski & Patejuk (2012: 485) is to "understand (non-)distributivity not as a property of features, but as a property of statements". This involves making statements distributive by default – non-distributive statements must be marked explicitly (with "@"). As Przepiórkowski & Patejuk (2012: 485) point out, "An interesting consequence of this proposal is that a given feature may behave distributively in some ways and non-distributively in others.", providing CASE as an example: while it is a non-distributive attribute in Polish, an additional distributive statement is used to ensure that each of the conjuncts bears an appropriate value of case.

The second solution described[32] in Przepiórkowski & Patejuk (2012: 486) is called "conservative" as it does not require any modifications to the LFG theory: it relies on the existing mechanism of off-path constraints. A distributive attribute (typically PRED, as below) is used as an anchor, so that the disjunctive constraint is distributed to each conjunct and evaluated independently: (127) is the off-path counterpart of (125), achieving its intended effect. This solution is presented in more detail in Patejuk & Przepiórkowski (2012a).

(127) $(\uparrow \text{OBJ} \underset{[(\leftarrow \text{CASE}) =_c \text{ACC} \lor (\leftarrow \text{COMP-FORM}) =_c \text{THAT}]}{\text{PRED}})$

[31] In Polish the subject requiring structural case can be – simplifying – nominative or, if it is a non-agreeing numeral, accusative, or a coordination of these. Apart from this, some predicates may take verbal subjects (InfP or CP) which may be coordinated with NPs bearing structural case.

[32] As explained in Przepiórkowski & Patejuk (2012), this solution is the idea of Mary Dalrymple.

Note that (127) uses constraining equations. While "plain" (not off-path) constraints can be defining (=, introducing an attribute-value pair) or constraining ($=_c$, checking if a given attribute-value pair is present), there are different formal views on off-path constraints. Some works assume these are non-constructive, which means that off-path constraints can only be constraining, so it is not possible to have defining off-path constraints – this is consistent with how off-path constraints work in XLE.[33] However, some theoretical works assume that off-path constraints can be constructive (see the discussion of (103) in Section 3.3), making it is possible to use these for introducing new attribute-value pairs.

This issue (whether off-path constraints can be constructive or not) is of significant importance in the context of unlike category coordination, since some constraints are typically defining – this includes control equations in examples such as (93), where one of the conjuncts requires control. As explained in Patejuk & Przepiórkowski (2014a), the control equation in (128)[34] would produce an ill-formed, incoherent f-structure because the non-infinitival conjunct does not take a subject. The disjunctive constraint in (129), aiming to address this issue, would also not work – as explained above, instead of being distributed as in (126a), it would be interpreted as in (126b): depending on which disjunct is chosen, one of the conjuncts would not satisfy the chosen constraint. (130) is the off-path version of (129) – whether it would have the intended effect depends on whether off-path constraints can be constructive.

(128) $(\uparrow \textsc{subj})=(\uparrow \textsc{obj subj})$

(129) $[(\uparrow \textsc{obj cat})=_c \textsc{inf} \wedge (\uparrow \textsc{subj})=(\uparrow \textsc{obj subj})] \vee (\uparrow \textsc{obj cat}) \neq \textsc{inf}$

(130) $$(\uparrow \textsc{obj} \underset{\substack{[(\leftarrow \textsc{cat})=_c \textsc{inf} \;\wedge\; (\leftarrow \textsc{subj})=((\textsc{obj} \leftarrow) \textsc{subj})] \\ \vee \\ (\leftarrow \textsc{cat}) \neq \textsc{inf}}}{\textsc{pred}})$$

To avoid the potential issue with (130) (since off-path constraints are non-constructive in XLE, this is a real issue for implemented grammars), Patejuk & Przepiórkowski (2014a) describe an alternative solution, again due to Mary Dalrymple: the idea is to use a dedicated attribute, CONTROLLER, to host the controller.

Let us consider again the example in (93), where the complement of CHCIEĆ 'want' consists of an infinitival phrase controlled by the subject and a noun

[33] https://ling.sprachwiss.uni-konstanz.de/pages/xle/doc/notations.html#N4.1.5b

[34] As mentioned in footnote 22, OBL may be more appropriate than OBJ for the coordinate phrase in (93).

phrase bearing structural case. Under this alternative proposal, instead of (128), the lexical entry of CHCIEĆ introduces the modified control equation in (131). As a consequence, the subject of CHCIEĆ is structure-shared with the CONTROLLER attribute of its OBJ complement. This does not trigger the coherence violation in the NP conjunct that is caused by (128).

(131) (↑ SUBJ)=(↑ OBJ CONTROLLER)

In the absence of (128) the InfP conjunct would be incomplete (its SUBJ needs to be filled), so the constraint in (132) is used instead to satisfy completeness. When used inside the InfP, (132) structure-shares the value of its CONTROLLER attribute with its SUBJ, providing the InfP complement of CHCIEĆ with a subject.

(132) (↓ CONTROLLER)=(↓ SUBJ)

Together, (131) and (132) make it possible to satisfy completeness by providing the InfP with a controller for its subject without violating coherence in non-infinitival conjuncts in examples such as (93).[35] This solution can also be used for unlike modifiers in (96)–(98).

It is worth noting that the CONTROLLER attribute introduced by (131) is represented in each conjunct, no matter whether a given conjunct requires control (as the infinitival conjunct in (93)) or not (as the nominal conjunct in (93)). CONTROLLER would be present even if there is no conjunct requiring control. If this is considered an issue, the restriction operator (!) can be used to remove the CONTROLLER attribute where is not necessary.

As mentioned above, the complement of CHCIEĆ 'want' may be an NP taking structural case (accusative or genitive, depending on the presence of sentential negation) or a controlled InfP. This is formalised in (133) using off-path constraints (non-constructive):

(133)
$$(\uparrow \textsc{obj} \underset{\substack{[(\leftarrow \textsc{cat}) =_c \textsc{inf}\ \wedge\ (\leftarrow \textsc{subj}) =_c ((\textsc{obj}\ \leftarrow)\ \textsc{subj})] \\ \vee \\ [(\leftarrow \textsc{cat}) =_c \textsc{n}\ \wedge \\ [[\neg((\textsc{obj}\ \leftarrow)\ \textsc{neg})\ \wedge\ (\leftarrow \textsc{case}) =_c \textsc{acc}]\ \vee \\ [((\textsc{obj}\ \leftarrow)\ \textsc{neg}) =_c +\ \wedge\ (\leftarrow \textsc{case}) =_c \textsc{gen}]]]}}{\textsc{pred}})$$

[35] The CONTROLLER attribute could also be used to host the controller of predicative complements, providing an alternative solution to the problem of predicative complements that have a subject of their own such as gerunds or CPs (Dalrymple et al. 2004). While standard open complement (XCOMP(-PRED)) analyses result in incoherence (two different values of SUBJ – one internal vs. one resulting from control), there would be no such problem when control is established via CONTROLLER.

While off-path constraints make it possible to impose disjunctive constraints under coordination, the resulting constraints are rather complex and hard to read. If off-path constraints are non-constructive (as in XLE), this limitation forces a special way of imposing constraints (defining constraints must be used elsewhere, as shown above).

Alternative solutions include the "liberal" solution of Przepiórkowski & Patejuk (2012) discussed above (making distributivity a property of statements, so that statements are distributive by default, while non-distributive statements must be marked as such).

Kaplan (2017: 133–4, fn. 6) offers another alternative, proposing to formalise the idea of the "liberal" solution of Przepiórkowski & Patejuk (2012) by introducing DISTRIB, "an explicit operator declaring that an arbitrary description *P* is a distributive property when it is applied to an f-structure *f* that happens to be a set":

(134) DISTRIB(f, v, P)

Kaplan (2017: 134) adds: "In any invocation (perhaps notated as a built-in template call) f will be a designator (e.g. ↑) and P will be a formula with a variable v that is bound in the scope of P to either the non-set designated by f or to each of its elements in turn."

(135) is the DISTRIB template call corresponding to the off-path constraint in (127), while (136) is the counterpart of (133). (136) is compatible with the CONTROLLER-based approach to establishing control relations shown in (131)–(132).

(135) @DISTRIB((↑ OBJ), %O, [(%O CASE)$=_c$ ACC ∨ (%O COMP-FORM)$=_c$ THAT])

(136) @DISTRIB((↑ OBJ), %O,
[(%O CAT)$=_c$ INF ∧ (↑ SUBJ)$=_c$(%O SUBJ)] ∨ [(%O CAT)$=_c$ N ∧
[[¬(↑ NEG) ∧ (%O CASE)$=_c$ ACC] ∨ [(↑ NEG) ∧ (%O CASE)$=_c$ GEN]]])

However, since constraints imposed using DISTRIB can be constructive, (137) can be used instead. It introduces a standard defining control equation ((↑ SUBJ)=(%O SUBJ) instead of (↑ SUBJ)$=_c$(%O SUBJ)), so there is no need to use the CONTROLLER attribute.

(137) @DISTRIB((↑ OBJ), %O,
[(%O CAT)$=_c$ INF ∧ (↑ SUBJ)=(%O SUBJ)] ∨ [(%O CAT)$=_c$ N ∧
[[¬(↑ NEG) ∧ (%O CASE)$=_c$ ACC] ∨ [(↑ NEG) ∧ (%O CASE)$=_c$ GEN]]])

The last alternative solution, proposed by Przepiórkowski & Patejuk (2021), is to reuse the formal device of local names (local variables) as a way of stating distributive properties – (138) is the counterpart of (127), while (139) corresponds to (133).

(138) $(\uparrow \text{OBJ})=\%\text{O} \wedge$
$[(\%\text{O CASE})=_c \text{ACC} \vee (\%\text{O COMP-FORM})=_c \text{THAT}]$

(139) $(\uparrow \text{OBJ})=\%\text{O} \wedge$
$[(\%\text{O CAT})=_c \text{INF} \wedge (\uparrow \text{SUBJ})=_c(\%\text{O SUBJ})] \vee [(\%\text{O CAT})=_c \text{N} \wedge$
$[[\neg(\uparrow \text{NEG}) \wedge (\%\text{O CASE})=_c \text{ACC}] \vee [(\uparrow \text{NEG}) \wedge (\%\text{O CASE})=_c \text{GEN}]]]$

As in the case of DISTRIB proposed by Kaplan (2017), constraints imposed in this way can also be constructive, so – as in (137) – it is possible to use (139) with a defining control equation in order to avoid using the CONTROLLER attribute to establish control.

While the "liberal" solution of Przepiórkowski & Patejuk (2012) makes statements (including disjunctive constraints) distributive (as in (126a); non-distributive properties need to be marked explicitly), the solutions proposed by Kaplan (2017) and Przepiórkowski & Patejuk (2021) are both "conservative" in the sense that statements are non-distributive (see (126b)) unless they are stated using the DISTRIB template or local names, respectively.

4 Coordination of unlike grammatical functions

Coordination can be even more unlike than when unlike categories are involved: in some languages it is possible to coordinate unlike grammatical functions under some circumstances. This is very robust in Slavic, Romanian and Hungarian, but it is also possible, to a lesser extent, in other languages, including English. This phenomenon has been discussed in the literature under different names, including: "lexico-semantic coordination" (Sannikov 1979, 1980, Mel'čuk 1988), "hybrid coordination" (Chaves & Paperno 2007) and "heterofunctional coordination" (Przepiórkowski 2022). While this type of coordination is sometimes referred to as "wh-coordination" (Bîlbîie & Gazdik 2012) when the discussion is restricted to interrogative items (as in (140)),[36] there are many more possible types of conjuncts, corresponding to different types of quantifiers: the universal quantifier in (141), the existential quantifier (indefinite pronouns in (142), free choice pronouns in (143)), *n*-words in (144) (existential quantifier in scope of negation), etc. The basic generalisation is that this variety of coordination joins elements which

[36] All examples used in this section are in Polish. Except for (148), all examples are from Patejuk (2015). Some glosses and translations have been modified.

belong to the same (restricted) semantic type, but they correspond to different grammatical functions.

(140) Polish
[[Kogo] i [komu]] przedstawił?
who.ACC and who.DAT introduced
'Who did he introduce to whom?' (Kallas 1993: 121, (241))

(141) Polish
Obiecać można [[wszystko] i [wszystkim]].
promise may everything.ACC and everyone.DAT
'One may promise everything to everyone.' (NKJP)

(142) Polish
[[Ktoś], [gdzieś] i [coś]] mocno pokiełbasił.
someone.NOM somewhere and something.ACC really messed up
'Someone really messed something up somewhere.' (NKJP)

(143) Polish
czy [[komukolwiek], [kiedykolwiek] i [do czegokolwiek]]
PRT anybody.DAT anytime and for anything
przydał się poradnik
come in handy guide
'Has a(ny) guide ever come in handy to anybody for anything?' (NKJP)

(144) Polish
[[nikogo] i [nic]] nie może tłumaczyć.
nobody.GEN and nothing.NOM NEG can excuse
'Nothing can excuse anybody.' (NKJP)

4.1 Is this really coordination?

When discussing coordination of different grammatical functions, a fundamental question arises: is this really coordination? For instance, in Polish the word *i* can be a conjunction, but it can also be an interjection or a particle. So perhaps the word that seems to be a conjunction in this construction is not a conjunction (but some other element) and such examples do not involve coordination. Patejuk & Przepiórkowski (2012b), Patejuk (2015), Patejuk & Przepiórkowski (2019) present a range of arguments showing that coordination of different grammatical functions is a genuine instance of coordination.

As pointed out in Patejuk & Przepiórkowski (2019: 28): "in all languages which allow for joining different grammatical functions the joining element has the same form as a conjunction" – and different conjunctions may be used, as shown below.

There are examples with unambiguous conjunctions, such as *oraz* in (145).

(145) Polish
[[kto] oraz [kiedy]] miałby płacić za postawiony budynek
who.NOM and when should pay for erected building
'Who and when would be supposed to pay for the erected building?' (NKJP)

There are examples such as (146) where other interpretations exist, but these are not appropriate in the given context. Apart from the conjunction, the only alternative interpretation of *lub* is as an imperative verb form, clearly not suitable in (146).

(146) Polish
Mile widziane odpowiedzi merytoryczne, bez przypuszczeń
welcome responses substantive without speculating
[[kto] lub [czego]] będzie w Wikipedii szukał.
who.NOM or what.GEN AUX in Wikipedia seek
'Welcome are substantive responses, without speculating who will seek what in Wikipedia.' (NKJP)

Some conjunctions have special requirements – for instance, *ani* 'neither/nor' belongs to *n*-words, so it needs negation to be licenced. As shown in (147), removing negation results in ungrammaticality, which is consistent with the behaviour of the conjunction *ani*.

(147) Polish
Nigdy nie wyjeżdżałyśmy na wakacje, bo *(nie) miałyśmy [[z
never NEG leave for holidays because NEG had with
kim] ani [za co]]…
who.INS nor for what.ACC
'We would never go on holiday because there was nobody we could go with and there was no money to go.' (Joanna Bator, *Ciemno, prawie noc*, 119)

Some examples, apart from a conjunction, also include a preconjunction, as in (148).

(148) Polish

…kiedy wyjawisz [nie tylko [kto], ale i [dlaczego]] otrzymał
when disclose not only who.NOM but and why received
awans.
promotion
'…when you explain not only who, but also why got promoted.'
(Patejuk & Przepiórkowski 2019: (9))

Finally, it is possible to coordinate more than two items – see (142) and (143).

Summing up, there is substantial evidence showing that different grammatical functions are joined with a conjunction and the construction in question is a variety of coordination.

4.2 How to represent such coordination?

Having established that coordination of different grammatical functions is indeed an instance of coordination, the next question is how it should be represented.

Patejuk & Przepiórkowski (2012b) offer an analysis with two possible representations: monoclausal (involving one clause, where all conjuncts are dependents of the same clause) or multiclausal (involving more than one clause, where conjuncts are dependents of different clauses; this is equivalent to clause-level coordination with ellipsis). It may be the case that the two different representations are needed in the same language, as in Polish.

Patejuk (2015) provides a critical review of various diagnostics/arguments for determining the right representation for coordination of different grammatical functions. While there are cases when it is necessary to adopt the multiclausal representation (for instance, when the conjuncts cannot belong to the same clause, see Section 4.4), it is hard to rule out the multiclausal representation elsewhere, unless it is assumed that ellipsis only operates under identity. Without this assumption, it is difficult to argue against arbitrary ellipsis mechanisms (which may be arbitrarily powerful). Due to this, it seems reasonable to assume that unless there are good reasons to adopt the multiclausal analysis, the monoclausal analysis should be preferred by default as the more economic representation.

The analysis presented below is the one proposed in Patejuk (2015) (which is an improved version of Patejuk & Przepiórkowski (2012b)). (149) is the topmost rule corresponding to the coordination of different grammatical functions; the two disjuncts on the right-hand side correspond to two different representations discussed in detail in the following subsections: XPlxm$_{type}$ is monoclausal (Section 4.3),[37] while XPlxb$_{type}$ is bi/multiclausal (Section 4.4).

(149) anyLEXSEM $\longrightarrow \left\{ \begin{array}{c|c} \text{XPlxm}_{type} & \text{XPlxb}_{type} \\ \downarrow\in(\uparrow \text{UDF}) & \end{array} \right\}$

The category anyLEXSEM is mostly intended to be used as the initial[38] dependent of S (or CP): (150) is a modified version of (16). Since conjuncts inside anyLEXSEM have appropriate annotations (including GF), anyLEXSEM has no annotation (same as ↓=↑).

(150) S $\longrightarrow$ anyLEXSEM VP

4.3 Monoclausal

The monoclausal representation is appropriate for coordination of different grammatical functions when all conjuncts can be dependents of the same clause. This has been the case in all examples so far. However, conjuncts do not have to be dependents of the same head. There are examples where they depend on different heads, as in (144) and below:

(151) Polish
[[Skąd] i [jakie]] otrzymujemy informacje?
whence and what.ACC receive information.ACC
'What information and from where do we receive?' (NKJP)

(152) Polish
[[Jakie] i [kto]] może ponieść konsekwencje?
what.ACC and who.NOM can bear consequences.ACC
'Who can suffer what consequences?' (Google)

(153) Polish
[[Ile] i [czego]] znaleźli?
how much.ACC and what.GEN found
'How much, and (of) what, did they find?' (NKJP)

In (144) the first conjunct (*nikogo* 'nobody') is the object of the infinitival complement (*tłumaczyć* 'excuse'), while the second conjunct (*nic* 'nothing') is the subject of the main verb (*może* 'can'). In (151) the first conjunct (*skąd* 'from where')

[37] UDF (unbounded dependency function, Asudeh (2011)) is a discourse function used instead of TOPIC/FOCUS, which makes it possible to avoid putting information structure in f-structure.
[38] Examples such as (147) show that such coordination can also be used non-initially.

is a modifier of the verb (*otrzymujemy* 'get'), while the second conjunct (*jakie* 'what') is a modifier of the verb's object (*informacje* 'information'). (152) is similar to (144) and (151): the first conjunct (*jakie* 'what') is the modifier of the object (*konsekwencje* 'consequences') of the infinitival complement (*ponieść* 'suffer'), while the second conjunct (*kto* 'who') is the subject of the main verb (*może* 'can'). (153) is different from previous examples because one conjunct depends on the other:[39] while the first conjunct (*ile* 'how much') is the object of the verb (*znaleźli* 'found'), the second conjunct (*czego* 'what') is the nominal complement of *ile*.[40]

The formalisation of Patejuk (2015) relies on the following components:

(154)
$$\begin{array}{ccccccc} \text{XPlxm}_{type} & \longrightarrow & \text{XPlxmC}_{type} & [, & \text{XPlxmC}_{type}]^{*} & \text{Conj} & \text{XPlxmC}_{type} \\ & & \downarrow\in\uparrow & & \downarrow\in\uparrow & & \downarrow\in\uparrow \end{array}$$

(155) $\text{XPlxmC}_{type} \longrightarrow \left\{ \text{XPextr}_{type} \,\middle|\, \text{XPlxm}_{type} \right\}$

(156)
$$\begin{array}{ccc} \text{XPextr}_{type} & \longrightarrow & \text{XP}_{type} \\ & & \uparrow=\downarrow \\ & & ((\textsc{udf} \in^{*} \uparrow)\ \textsc{xpath}\ \textsc{gf}^{+})=\downarrow \end{array}$$

(157) $\text{XP}_{type} \equiv \{\text{NP}|\text{PP}|\text{ADVP}|\text{AP}\}_{type}$

(158) $type \equiv \{\, all \mid any \mid int \mid neg \,\}$

(159) $\textsc{xpath} \equiv \textsc{xcomp}^{*}$

(160) $\textsc{gf} \equiv \{\textsc{subj}|\textsc{obj}|\textsc{obj}_{\theta}|\textsc{obl}|\textsc{adj} \in\}$

All rules in (154)–(157) use the $_{type}$ variable defined in (158) – its value must be the same on both sides of the rule. (154) is the topmost rule corresponding to monoclausal (hence "m" in XPlxm) coordination of different grammatical functions ("lx" in XPlxm stands for "lexico-semantic", the term first used in Sannikov (1979, 1980) to refer to such coordination). XPlxm_{type} rewrites to a sequence of XPlxmC_{type} conjuncts (hence "C" in XPlxmC) – it is only possible to coordinate conjuncts belonging to the same semantic type (listed in (158)). (155) rewrites XPlxmC_{type} to XPextr_{type} (no embedding) or XPlxm_{type}, which makes it possible

[39] ZNALEŹĆ 'find' cannot take a genitive partitive object, so *czego* cannot be its object: **Czego znaleźli?*

[40] In Polish, the numeral phrase is headed by the numeral which takes a nominal complement (with agreeing numerals, the complement has the same case; with non-agreeing numerals it is genitive).

to embed such coordination. (156) rewrites XPextr_{type} to XP_{type} – the metacategory[41] defined in (157) as a disjunction of categories of the same $_{type}$.

Together with (149)–(150), these produce the following monoclausal f-structure for (151):

(161)
$$\begin{bmatrix} \text{PRED} & \text{`RECEIVE}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\begin{bmatrix}\text{PRED} & \text{`PRO'}\end{bmatrix} \\ \text{OBJ} & \boxed{2}\begin{bmatrix} \text{PRED} & \text{`INFORMATION'} \\ \text{CASE} & \text{ACC} \\ \text{ADJ} & \{\boxed{3}\}\end{bmatrix} \\ \text{ADJ} & \{\boxed{4}\} \\ \text{UDF} & \left\{\begin{bmatrix} \left\{ \boxed{4}\begin{bmatrix}\text{PRED} & \text{`WHENCE'} \\ \text{TYPE} & \text{INT}\end{bmatrix}, \boxed{3}\begin{bmatrix}\text{PRED} & \text{`WHAT'}\\ \text{CASE} & \text{ACC} \\ \text{TYPE} & \text{INT}\end{bmatrix}\right\} \\ \text{CONJ} \quad \text{AND}\end{bmatrix}\right\}\end{bmatrix}$$

(Patejuk 2015: (5.125))

To see how the monoclausal analysis of Patejuk (2015) works, let us consider its procedural intuition showing how (161) is built using the rules in (149)–(150) and (154)–(160).

(162) and (163) are the partial f-structures built by the words *skąd* and *jakie*, respectively:

(162)
$$\begin{bmatrix}\text{PRED} & \text{`WHENCE'} \\ \text{TYPE} & \text{INT}\end{bmatrix}$$

(163)
$$\begin{bmatrix}\text{PRED} & \text{`WHAT'} \\ \text{CASE} & \text{ACC} \\ \text{TYPE} & \text{INT}\end{bmatrix}$$

These words are interrogative (their lexical entries specify the value of the TYPE attribute as INT), so they correspond to categories ADVP_{int} and AP_{int}, respectively. According to (157), each of these categories is an instance of XP_{int} metacategory. Following (155)–(156), XPextr_{int} rewrites to XP_{int} and XPlxmC_{int} to XPextr_{int}, so: $\text{XPlxmC}_{int} \longrightarrow \text{XPextr}_{int} \longrightarrow \text{XP}_{int}$. Next, the rule in (154) adds XPlxmC_{int} conjuncts to a set, building the f-structure in (164), which contains the f-structures in (162) and (163) as set elements. Then the rule in (149) rewrites

[41] Unlike XPlxm_{type}, XPlxmC_{type} and XPextr_{type} (and all other symbols whose name includes the XP substring), XP_{type} is a metacategory: $\equiv$ is used instead of $\longrightarrow$ as the rewrite symbol in the rule defining XP_{type}, so the right-hand side categories in (157) appear in c-structure instead of XP_{type}.

anyLEXSEM to XPlxm$_{int}$ with $\downarrow\in(\uparrow$ UDF) annotation. As a result, the f-structure in (164) is added as a member of the UDF set, see (165).

(164)
$$\left[\begin{array}{l} \left\{ \begin{bmatrix}\text{PRED} & \text{`WHENCE'}\\ \text{TYPE} & \text{INT}\end{bmatrix}, \begin{bmatrix}\text{PRED} & \text{`WHAT'}\\ \text{CASE} & \text{ACC}\\ \text{TYPE} & \text{INT}\end{bmatrix} \right\} \\ \text{CONJ} \quad \text{AND}\end{array}\right]$$

(165)
$$\begin{bmatrix} \text{OBJ} & \begin{bmatrix}\text{ADJ} & \{\boxed{3}\}\end{bmatrix} \\ \text{ADJ} & \{\boxed{4}\} \\ \text{UDF} & \left\{ \left[\begin{array}{l} \left\{ \boxed{4}\begin{bmatrix}\text{PRED} & \text{`WHENCE'}\\ \text{TYPE} & \text{INT}\end{bmatrix}, \boxed{3}\begin{bmatrix}\text{PRED} & \text{`WHAT'}\\ \text{CASE} & \text{ACC}\\ \text{TYPE} & \text{INT}\end{bmatrix} \right\} \\ \text{CONJ} \quad \text{AND}\end{array}\right] \right\} \end{bmatrix}$$

It is now possible to see and explain the effect of the rule in (156), where XP$_{int}$ has two annotations. While $\uparrow=\downarrow$ builds the f-structures in (162)–(163), which are later used to build the coordinate f-structure in (164), ((UDF $\in^* \uparrow$) XPATH GF$^+$)=$\downarrow$ structure-shares the f-structure of each conjunct. (UDF $\in^* \uparrow$) is the path to the top-level f-structure containing the UDF attribute, XPATH defined in (159) produces any sequence (including zero) of XCOMPs (making it possible to embed the f-structure inside verb chains), while GF$^+$ produces any non-zero sequence of GFs defined in (160). Together, these equations make it possible to structure-share each conjunct inside the UDF set with any grammatical function that can be reached using this path. As a result of this annotation, in (165) the f-structure $\boxed{4}$ corresponding to *skąd* is structure-shared with the element of the ADJ set at the main level (via resolved ((UDF $\in^* \uparrow$) ADJ $\in$)=$\downarrow$ annotation, equivalent to $\downarrow \in$ ((UDF $\in^* \uparrow$) ADJ)), while the f-structure $\boxed{3}$ corresponding to *jakie* is structure-shared with the element of the ADJ set of the OBJ attribute at the main level (via resolved ((UDF $\in^* \uparrow$) OBJ ADJ $\in$)=$\downarrow$, equivalent to $\downarrow \in$ ((UDF $\in^* \uparrow$) OBJ ADJ)).

Finally, using the rule in (150), the partial f-structure in (165) corresponding to the coordination of different grammatical functions (*skąd i jakie* 'where from and what') is unified with the partial f-structure in (166) corresponding to the rest of the sentence (*otrzymujemy informacje* '(we) get information'), yielding the final f-structure in (161) – a monoclausal representation where all conjuncts belong to the same clause (even though they depend on different heads).

(166)
$$\begin{bmatrix} \text{PRED} & \text{`RECEIVE}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\begin{bmatrix}\text{PRED} & \text{`PRO'}\end{bmatrix} \\ \text{OBJ} & \boxed{2}\begin{bmatrix}\text{PRED} & \text{`INFORMATION'}\\ \text{CASE} & \text{ACC}\end{bmatrix} \end{bmatrix}$$

4.4 Multiclausal (including biclausal)

The multiclausal representation, unlike the monoclausal one, is appropriate for instances of coordination of different grammatical functions where conjuncts are dependents of different clauses. Such a representation is suitable when conjuncts cannot be codependents (as in Polish where certain examples would otherwise be ungrammatical). While it may also be preferred for other reasons (as in English and other languages with optional arguments but without pro-drop), this will not be discussed here for reasons of space.

In Polish, there are two cases where the multiclausal analysis of coordination of different grammatical functions is necessary: coordination of the *yes*/*no* interrogative particle CZY with another interrogative item, as in (167), and coordination of relatives, see (168):

(167) Polish
Nie wiadomo było, [[czy] *(i) [kiedy]] wróci.
NEG know was PRT and when returns
'It was not clear whether and when (s)he/it would return.' (NKJP)

(168) Polish
SŁOWA tej księgi pozwalają budować człowieka [[któremu] *(i)
words this book let build man who.DAT and
[z którym]] jest dobrze żyć.
with whom is good live
'Words of this book let one build a man for and with whom it is good to live.' (NKJP)

Patejuk (2015) proposes two representations for multiclausal coordination of different grammatical functions: one involves as many clauses as conjuncts (Section 4.4.1), while the other always involves two clauses (Section 4.4.2). While only the "as many clauses as conjuncts" representation is appropriate for coordination of relatives, coordination of CZY with other interrogative items may be analysed using either representation. The difference is visible with more than two conjuncts, so let us consider an example with three conjuncts:

(169) Polish
[[Czy], [kiedy] i [kto]] zajmie się drogami [...] nie wiadomo.
PRT when and who.NOM take care roads.INS NEG known
'It is not known, whether, who and when will take care of the roads.' (NKJP)

4.4.1 As many clauses as conjuncts

These rules produce the representation where it is possible to have more than two clauses:

(170)
$$\text{XPlxb}_{rel} \longrightarrow \begin{array}{c}\text{XPextrbicl}_{rel}\\ \downarrow\in\uparrow\end{array} \quad \begin{array}{c}[,\ \text{XPextrbicl}_{rel}]^{*}\\ \downarrow\in\uparrow\end{array} \quad \text{Conj} \quad \begin{array}{c}\text{XPextrbicl}_{rel}\\ \downarrow\in\uparrow\end{array}$$

(171)
$$\text{XPlxb}_{int} \longrightarrow \begin{array}{c}\text{PARTbicl}_{int}\\ \downarrow\in\uparrow\end{array} \quad \begin{array}{c}[,\ \text{XPextrbicl}_{int}]^{*}\\ \downarrow\in\uparrow\end{array} \quad \text{Conj} \quad \begin{array}{c}\text{XPextrbicl}_{int}\\ \downarrow\in\uparrow\end{array}$$

(172)
$$\text{PARTbicl}_{type} \longrightarrow \begin{array}{c}\text{PART}_{type}\\ \uparrow=\downarrow\\ @\text{PRODROP}\end{array}$$

(173)
$$\text{XPextrbicl}_{type} \longrightarrow \begin{array}{c}\text{XPextr}_{type}\\ \downarrow\in(\uparrow\ \text{UDF})\\ @\text{PRODROP}\end{array}$$

(174)
$$\text{PRODROP} \equiv \begin{array}{l}((\uparrow\ \text{SUBJ PRED})=\text{`PRO'})\\ ((\uparrow\ \text{OBJ PRED})=\text{`PRO'})\\ \ldots\\ ((\uparrow\ \text{GF PRED})=\text{`PRO'})\end{array}$$

(170)–(171) are the topmost rules handling bi/multiclausal (hence "b' in XPlxb, while "m" stands for "monoclausal" in XPlxm) coordination of different grammatical functions where XPlxb rewrites to a sequence of conjuncts: relative (XPextrbicl_{rel}) in (170), or interrogative in (171) – with PARTbicl_{int} (the *yes/no* interrogative particle CZY) as the first conjunct and XPextrbicl_{int} as the remaining conjuncts. According to (172)–(173), PARTbicl_{type} and XPextrbicl_{type} rewrite to PART_{type} and XPextr_{type}, respectively; both right-hand side categories contain calls to the PRODROP template defined in (174). It contains conjoined optional statements, so each call may optionally introduce various implicit arguments (in case these are not filled locally, which would violate completeness).

Together with (149)–(150) and (156)–(160), rules in (171)–(174) produce the following multiclausal f-structure for (169) (leaving out the contribution of *nie wiadomo*):

(175)
$$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{PRED} & \text{`TAKE\_CARE}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED `PRO'}\right] \\ \text{OBL} & \boxed{2}\left[\text{PRED `ROADS'}\right] \\ \text{CLAUSE-TYPE} & \text{INT} \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`TAKE\_CARE}\langle\boxed{3},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{3}\left[\text{PRED `PRO'}\right] \\ \text{OBL} & \boxed{2} \\ \text{ADJ} & \left\{\boxed{4}\right\} \\ \text{UDF} & \left\{\boxed{4}\left[\begin{array}{ll}\text{PRED} & \text{`WHEN'}\\ \text{TYPE} & \text{INT}\end{array}\right]\right\} \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`TAKE\_CARE}\langle\boxed{5},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{5} \\ \text{OBL} & \boxed{2} \\ \text{UDF} & \left\{\boxed{5}\left[\begin{array}{ll}\text{PRED} & \text{`WHO'}\\ \text{TYPE} & \text{INT}\end{array}\right]\right\} \end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND} \end{array}\right]$$

(Patejuk 2015: (5.239))

To better understand this multiclausal analysis, let us consider its procedural intuition showing how the f-structure in (175) is built using the rules listed above.

(176)–(178) are the f-structures built by the words *czy* 'whether', *kiedy* 'when' and *kto* 'who' which correspond to categories PART$_{int}$, ADVP$_{int}$ and NP$_{int}$, respectively:

(176) $\left[\text{CLAUSE-TYPE} \quad \text{INT}\right]$

(177) $\left[\begin{array}{ll} \text{PRED} & \text{`WHEN'} \\ \text{TYPE} & \text{INT} \end{array}\right]$

(178) $\left[\begin{array}{ll} \text{PRED} & \text{`WHO'} \\ \text{TYPE} & \text{INT} \end{array}\right]$

According to (157), ADVP$_{int}$ and NP$_{int}$ are instances of the XP$_{int}$ metacategory. The rule in (173) rewrites XPextrbicl$_{int}$ to XPextr$_{int}$, while (156) rewrites XPextr$_{int}$ to XP$_{int}$ (so: XPextrbicl$_{int}$ $\longrightarrow$ XPextr$_{int}$ $\longrightarrow$ XP$_{int}$). The rule in (172) rewrites PARTbicl$_{int}$ to PART$_{int}$. The f-structures below built by these rules contain the contributions of calls to the PRODROP template as well as structure-sharing via UDF (resulting from the annotation in (156)): (179) corresponds to PARTbicl$_{int}$, while (180)–(181) correspond to XPextrbicl$_{int}$.

(179) $\left[\begin{array}{ll} \text{SUBJ} & \left[\text{PRED} \quad \text{`PRO'}\right] \\ \text{CLAUSE-TYPE} & \text{INT} \end{array}\right]$

(180) $\left[\begin{array}{ll} \text{SUBJ} & \boxed{5} \\ \text{UDF} & \left\{ \boxed{5} \left[\begin{array}{ll} \text{PRED} & \text{`WHO'} \\ \text{TYPE} & \text{INT} \end{array}\right] \right\} \end{array}\right]$

(181) $\left[\begin{array}{ll} \text{SUBJ} & \left[\text{PRED} \quad \text{`PRO'}\right] \\ \text{ADJ} & \left\{\boxed{4}\right\} \\ \text{UDF} & \left\{ \boxed{4} \left[\begin{array}{ll} \text{PRED} & \text{`WHEN'} \\ \text{TYPE} & \text{INT} \end{array}\right] \right\} \end{array}\right]$

(179) consists of (176) (contributed by *czy*, the first conjunct) and an implicit subject introduced by the first optional equation in the PRODROP template defined in (174). (181) consists of (177) (contributed by *kiedy*, the second conjunct) added to the UDF set using (173) as $\boxed{4}$ and structure-shared using (156) as a member of the ADJ set of the main-level f-structure; it also contains an implicit subject

introduced by PRODROP. (180) consists of (178) (contributed by *kto*, the third conjunct) added to the UDF set as $\boxed{5}$ and structure-shared with the value of the SUBJ attribute of the main-level f-structure. (180) does not contain any contributions of PRODROP – all statements in (174) are optional.

Using the rule in (171) which handles coordination of interrogative items corresponding to different grammatical functions, the f-structures in (179)–(181) are added to a set, yielding the f-structure in (182) which corresponds to XPlxb_{int}. The rule in (149) rewrites anyLEXSEM to XPlxb_{int} without any annotation (so it is interpreted as ↓=↑ by default).

(182)
$$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{SUBJ} & [\text{PRED} \ \text{`PRO'}] \\ \text{CLAUSE-TYPE} & \text{INT} \end{array}\right], \left[\begin{array}{ll} \text{SUBJ} & [\text{PRED} \ \text{`PRO'}] \\ \text{ADJ} & \{\boxed{4}\} \\ \text{UDF} & \left\{\boxed{4}\left[\begin{array}{ll} \text{PRED} & \text{`WHEN'} \\ \text{TYPE} & \text{INT} \end{array}\right]\right\} \end{array}\right], \left[\begin{array}{ll} \text{SUBJ} & \boxed{5} \\ \text{UDF} & \left\{\boxed{5}\left[\begin{array}{ll} \text{PRED} & \text{`WHO'} \\ \text{TYPE} & \text{INT} \end{array}\right]\right\} \end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND} \end{array}\right]$$

(183)
$$\left[\begin{array}{ll} \text{PRED} & \text{`TAKE\_CARE}\langle\text{SUBJ,}\boxed{2}\rangle\text{'} \\ \text{OBL} & \boxed{2}[\text{PRED} \ \text{`ROADS'}] \end{array}\right]$$

Finally, using the rule in (150), the f-structure in (182) corresponding to the coordination of different grammatical functions (*czy, kiedy i kto* 'whether, when and who') is unified with the f-structure in (183) corresponding to the rest of the sentence (*zajmie się drogami* 'will take care of the roads'), yielding (175) as the final f-structure for (169) – it is a multiclausal representation where each conjunct belongs to a different clause.

While the multiclausal representation presented above is simple (there are as many clauses as conjuncts), it has some shortcomings. Since each clause has its own call to the PRODROP template, this can result in multiple implicit pronouns, as in (175) where the first two clauses have different implicit subjects – even though they look the same, they are distinct entities. While this could be solved by coindexation, such a representation is not economic.

There is another issue related to economy of representation: while the *yes/no* interrogative particle CZY cannot be placed in the same clause as other interrogative items (such as *skąd* 'where' or *kto* 'who'), interrogative items other than CZY can be co-dependents, which means these could be placed in the same clause. This observation is the reason for exploring the alternative multiclausal (biclausal) representation discussed in Section 4.4.2 below.

4.4.2 Always two conjuncts

The following rules are used to obtain a biclausal representation of coordination of different grammatical functions – one that always involves two coordinated clauses: the first clause contains PARTbicl$_{int}$, while the second one contains XPextrbicl$_{int}$. If such coordination involves more than two conjuncts, as in (169), the second clause is analysed an instance of monoclausal coordination of different grammatical functions (XPlxm$_{type}$, see Section 4.3) – such cases involve embedded monoclausal coordination in the second conjunct.

(184) $$\text{XPlxb}_{int} \longrightarrow \begin{array}{c}\text{PARTbicl}_{int}\\ \downarrow\in\uparrow\end{array} \quad \text{Conj} \quad \begin{array}{c}\text{XPextrbicl}_{int}\\ \downarrow\in\uparrow\end{array}$$

(185) $$\text{XPextrbicl}_{type} \longrightarrow \left\{ \begin{array}{c|c} \text{XPextr}_{type} & \text{XPlxm}_{type}\\ \downarrow\in(\uparrow \textsc{udf}) & \downarrow\in(\uparrow \textsc{udf})\\ @\textsc{prodrop} & @\textsc{prodrop} \end{array} \right\}$$

Together with (149)–(150), (156)–(160), (172) and (174), the rules in (184)–(185) produce the f-structure in (186) for (169). (186) consists of two clauses: the first one contains the *yes/no* interrogative particle CZY, while the second clause involves monoclausal coordination of *kiedy* 'when' and *kto* 'who' in the UDF attribute, whose elements are structure-shared with the relevant dependents of this clause (ADJ and SUBJ, respectively).

(186) $$\left\{ \begin{bmatrix} \textsc{pred} & \text{`TAKE\_CARE}\langle\boxed{1},\boxed{2}\rangle\text{'}\\ \textsc{subj} & \boxed{1}\begin{bmatrix}\textsc{pred} & \text{`PRO'}\end{bmatrix}\\ \textsc{obl} & \boxed{2}\begin{bmatrix}\textsc{pred} & \text{`ROADS'}\end{bmatrix}\\ \textsc{clause-type} & \textsc{int} \end{bmatrix}, \begin{bmatrix} \textsc{pred} & \text{`TAKE\_CARE}\langle\boxed{3},\boxed{2}\rangle\text{'}\\ \textsc{subj} & \boxed{3}\\ \textsc{obl} & \boxed{2}\\ \textsc{adj} & \left\{\boxed{4}\right\}\\ \textsc{udf} & \left\{\begin{bmatrix} \left\{ \boxed{4}\begin{bmatrix}\textsc{pred} & \text{`WHEN'}\\ \textsc{type} & \textsc{int}\end{bmatrix}, \boxed{3}\begin{bmatrix}\textsc{pred} & \text{`WHO'}\\ \textsc{type} & \textsc{int}\end{bmatrix} \right\}\\ \textsc{conj} \quad \textsc{and} \end{bmatrix}\right\} \end{bmatrix} \right\}$$

(Patejuk 2015: (5.244))

The f-structures produced by the words *czy*, *kiedy* and *kto* are the same as in (176)–(178).

While the f-structure corresponding to PARTbicl$_{int}$ is the same as in (179), the f-structure corresponding to XPextrbicl$_{int}$ is different from what is described in Section 4.4.1. According to the rule in (185), XPextrbicl$_{int}$ rewrites to XPextr$_{int}$ or XPlxm$_{int}$. (169) involves three conjuncts: the first one (*czy*) corresponds to PARTbicl$_{int}$, while the remaining two must be analysed as XPlxm$_{int}$ – as monoclausal coordination of different grammatical functions described in Section 4.3. Rules presented there produce the f-structure in (187) for *kiedy i kto*:

(187) $$\begin{bmatrix} \textsc{subj} & \boxed{3}\\ \textsc{adj} & \left\{\boxed{4}\right\}\\ \textsc{udf} & \left\{\begin{bmatrix} \left\{ \boxed{4}\begin{bmatrix}\textsc{pred} & \text{`WHEN'}\\ \textsc{type} & \textsc{int}\end{bmatrix}, \boxed{3}\begin{bmatrix}\textsc{pred} & \text{`WHO'}\\ \textsc{type} & \textsc{int}\end{bmatrix} \right\}\\ \textsc{conj} \quad \textsc{and} \end{bmatrix}\right\} \end{bmatrix}$$

Using the topmost rule for biclausal coordination of different grammatical functions in (184), the f-structures corresponding to PARTbicl_{int} and XPextrbicl_{int}, (179) and (187), respectively, are added to a set, producing the f-structure in (188) for *czy, kiedy i kto.*

(188)

$$\left\{ \begin{bmatrix} \textsc{subj} & \boxed{1}\begin{bmatrix} \textsc{pred} & \text{`}\textsc{pro}\text{'} \end{bmatrix} \\ \textsc{clause-type} & \textsc{int} \end{bmatrix}, \begin{bmatrix} \textsc{subj} & \boxed{3} \\ \textsc{adj} & \left\{\boxed{4}\right\} \\ \textsc{udf} & \left\{ \begin{bmatrix} \left\{ \boxed{4}\begin{bmatrix} \textsc{pred} & \text{`}\textsc{when}\text{'} \\ \textsc{type} & \textsc{int} \end{bmatrix}, \boxed{3}\begin{bmatrix} \textsc{pred} & \text{`}\textsc{who}\text{'} \\ \textsc{type} & \textsc{int} \end{bmatrix} \right\} \\ \textsc{conj} \quad \textsc{and} \end{bmatrix} \right\} \end{bmatrix} \right\}$$

Finally, the f-structure in (188) corresponding to *czy, kiedy i kto* is unified with the f-structure in (183) corresponding to the rest of the sentence (*zajmie się drogami*), yielding the f-structure in (186) as the final representation of (169).

Unlike (175) discussed in Section 4.4.1, the representation in (186) is biclausal: the first clause contains the first conjunct (*czy*), while the second clause contains remaining conjuncts (second *kiedy* and third *kto*) analysed as monoclausal coordination of different grammatical functions (Section 4.3). As a consequence, (186) uses only one implicit argument (the subject of the first clause), making it a more economic representation of (169) than (175).[42]

5 Coordination and ellipsis

This section discusses selected phenomena involving multiclausal structures and ellipsis. In German Subject Gap in Finite/Fronted (SGF) construction and Polish "intertwined" coordination a dependent is shared by clauses headed by different predicates, while gapping involves sharing at least the main predicate.

5.1 SGF: Subject Gap in Finite/Fronted construction

Frank (2002) offers an analysis of the German SGF:

(189) German
[[In den Wald ging der Jäger] und [fing einen Hasen]].
into the forest went the hunter and caught a rabbit
'The hunter went into the forest and caught a rabbit.' (Frank 2002: (4))

[42] The place where the conjunction is represented is another difference between (175) and (186). While in (175) it joins the three clauses, in (186) it joins the last two conjuncts inside the UDF set in the second clause. Patejuk (2015: 131) addresses this issue by copying the conjunction from UDF to the clause level.

As shown in (189), SGF involves coordination of clauses (headed by different verbs) with a shared subject which is placed inside the first clause (rather than to the left or to the right of the coordinated clauses, which would make dependent sharing straightforward).

Examples such as (189) are handled using (190), a dedicated c-structure rule for CP-level coordination which optionally structure-shares the GDF (grammaticalised discourse function) inside the first conjunct so that it is distributed across all conjuncts. While, following Bresnan (2001), GDF is defined in (191) as SUBJ, TOPIC or FOCUS, in German SGF it is further restricted – it must be the subject, as explained in Frank (2002).

(190)
$$\text{CP} \longrightarrow \begin{array}{c}\text{CP}\\ \downarrow\in\uparrow \\ ((\downarrow \text{GDF})=(\uparrow \text{GDF}))\end{array} \quad \text{Conj} \quad \begin{array}{c}\text{CP}\\ \downarrow\in\uparrow\end{array}$$

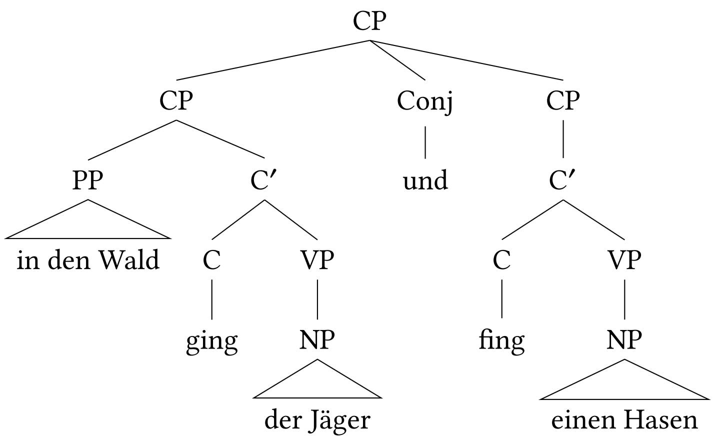
(191)
$$\text{GDF} \equiv \{\text{SUBJ}|\text{TOPIC}|\text{FOCUS}\}$$

The structures below,[43] created using (190), correspond to (189). Even though the NP *der Jäger* belongs exclusively to the first conjunct in the c-structure in (193), the corresponding f-structure fragment, $\boxed{1}$, is structure-shared by both conjuncts in (192).

(192)
$$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{PRED} & \text{`GO}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\text{PRED} \quad \text{`HUNTER'}\right] \\ \text{OBL} & \boxed{2}\left[\begin{array}{ll}\text{PRED} & \text{`INTO}\langle\boxed{3}\rangle\text{'}\\ \text{OBJ} & \boxed{3}\left[\text{PRED} \quad \text{`FOREST'}\right]\end{array}\right] \\ \text{TOPIC} & \boxed{2}\end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`CATCH}\langle\boxed{1},\boxed{4}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \\ \text{OBJ} & \boxed{4}\left[\text{PRED} \quad \text{`RABBIT'}\right]\end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND}\end{array}\right]$$

[43]The structures in (193)–(192) are a modified (normalised/translated) version of Frank (2002: (36)).

(193)



5.2 Sharing "intertwined" dependents

Discussing coordination data from Polish,[44] Patejuk & Przepiórkowski (2015) offer an analysis of "intertwined" dependents – dependents which are interpreted as shared by all conjuncts, even though they are placed inside the first conjunct, like the subject in German SGF discussed in Section 5.1. However, there are fewer restrictions in Polish – unlike in German, it seems that any dependent may be shared: subject in (194), object in (195) and even particles such as *się*, as in (196) where it is a reciprocal marker (RECP).

(194) Polish
[[Przyjechali żandarmi] i [chodzili od domu do
came.PL.M1 soldier.NOM.PL.M1 and walked.PL.M1 from house to
domu]].
house
'Soldiers came and walked from house to house.' (NKJP)

(195) Polish
[[Zakleiła kopertę] i [wepchnęła do torebki]].
sealed.SG.F envelope.ACC and pushed.SG.F into handbag
'She sealed the envelope and pushed it into the handbag.' (NKJP)

(196) Polish
[[Całowali się] i [przytulali]]!
kissed.PL.M1 RECP |RECP and hugged.PL.M1
'They were kissing and hugging each other!' (Google)

[44]Except for (203)–(204), all examples in Section 5.2 are from Patejuk & Przepiórkowski (2015).

While (194) and (195) could also be analysed as involving an implicit argument (an instance of pro-drop) in the second conjunct coreferent (via coindexation) with the appropriate argument (subject or object) in the first conjunct, this does not apply to (196). This is because *się* is analysed as a marker: it is not put on the list of arguments (the verbs in (196) only take a subject), so it cannot be analysed as an implicit argument.

As discussed in Patejuk & Przepiórkowski (2015), *się* can have many functions in Polish: it can be a reflexive/reciprocal marker, an impersonal marker, or it can be "inherent" – a semantically contentless particle that is required lexically by certain predicates. In (196) the shared *się* has the same function (reciprocal) with respect to both predicates (KISS and HUG) – this is glossed as RECP |RECP where | separates functions. In (197) the shared marker has a different function in each conjunct – as shown in (198), the first conjunct requires inherent *się* (INH), while the second conjunct takes reflexive *się* (REFL):

(197) Polish

[[Śmiali	się]	i	[pukali	w głowy]].
laughed.PL.M1	INH|REFL	and	knocked.PL.M1	in heads

'They were laughing and asking if somebody is nuts.' (literally: 'They were laughing and knocking themselves on their heads.')

(198) Polish

[[Śmiali	się]	i	[pukali	się	w głowy]].
laughed.PL.M1	INH	and	knocked.PL.M1	REFL	in heads

On the basis of examples such as (197), Patejuk & Przepiórkowski (2015) argue that the SGF analysis would not be appropriate: not only because *się* is not an argument (it is analysed as a marker, so it is not on the list of arguments), but also because it is a weak, unstressed form (as opposed to the pronoun *siebie* 'self'), so it cannot bear discourse functions such as TOPIC or FOCUS. Also, while the SGF analysis involves distributing a designated grammatical function of the first conjunct (the subject) over the entire coordination, Patejuk & Przepiórkowski (2015) show that structure sharing the f-structure contribution corresponding to *się* would not be adequate in (197), because the first conjunct requires a different type of *się* than the second conjunct, as shown in (198).

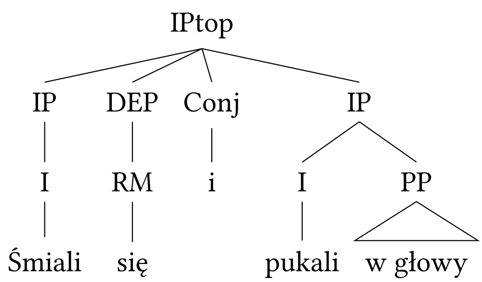
In Patejuk & Przepiórkowski (2015), the word *się* introduces two kinds of constraints: ($\uparrow$ SIE PRESENT) = +, a defining equation marking that this word is present in the f-structure, and a constraining equation ensuring that the type of *się* is specified elsewhere (by the verb, if it is required lexically, or constructionally for impersonal *się*). Verbs that lexically require *się* also introduce two constraints: a constraining equation requiring the presence of this marker, ($\uparrow$ SIE PRESENT) $=_c$ +, and a defining equation specifying the type of *się*: ($\uparrow$ SIE REFL) = + for reflexive *się* and ($\uparrow$ SIE INH) = + for inherent *się*. If one were to adopt an SGF-like analysis by structure-sharing the SIE attribute of the first conjunct with the entire coordination, the result would be incorrect. This is because the SIE attribute contains the contribution of *się* as well as the verb in the first conjunct, so it would not yield an appropriate analysis of (197): the second verb would have multifunctional *się* (inherent and reflexive), instead of having inherent *się* in the first conjunct and reflexive *się* in the second conjunct. In principle, this problem with the SGF-like analysis could be worked around by using the constraint ($\downarrow$ SIE PRESENT)=($\uparrow$ SIE PRESENT) instead of ($\downarrow$ SIE)=($\uparrow$ SIE) when sharing *się*.

However, instead of an SGF-like analysis, Patejuk & Przepiórkowski (2015) propose an alternative solution by introducing a rule handling coordination with "intertwined" dependents, see (199), where such dependents (DEP) are placed in the c-structure at the same level as the conjuncts (IP) and the conjunction (Conj). This way, the f-structure contribution of DEP, possibly disjunctive or underspecified, can be resolved independently for each conjunct, making it possible to account for examples such as (197). The rules in (199)–(200) produce the structures in (201)–(202) corresponding to (197).[45]

(199) $\text{IPtop} \longrightarrow \underset{\downarrow\in\uparrow}{\text{IP}} \quad \text{DEP} \quad \text{Conj} \quad \underset{\downarrow\in\uparrow}{\text{IP}}$

(200) $\text{DEP} \longrightarrow \left\{ \underset{(\uparrow \text{GF})=\downarrow}{\text{ARG}} \;\middle|\; \underset{\downarrow \in (\uparrow \text{ADJUNCT})}{\text{MOD}} \;\middle|\; \text{RM} \right\}$

(201)



[45] Additional constraints are used to structure-share the implicit subject in (197) (see also: (195)–(196)).

(202)
$$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \text{PRED} & \text{`LAUGH}\langle\boxed{1}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\\ \text{CASE} & \text{NOM}\\ \text{NUM} & \text{PL}\end{array}\right] \\ \text{SIE} & \left[\begin{array}{ll}\text{INH} & +\\ \text{PRESENT} & +\end{array}\right]\end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`KNOCK}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1} \\ \text{OBL} & \boxed{2}\left[\begin{array}{ll}\text{PRED} & \text{`HEAD'}\\ \text{PFORM} & \text{W}\end{array}\right] \\ \text{SIE} & \left[\begin{array}{ll}\text{REFL} & +\\ \text{PRESENT} & +\end{array}\right]\end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND} \end{array}\right]$$

(Patejuk & Przepiórkowski 2015: (64))

The defining equation (↑ SIE PRESENT) = + introduced by *się* is distributed across coordination in (201), together with the constraining equation requiring that the type of *się* is specified ((↑ SIE {REFL|RECP|INH}) $=_c$ +). The latter is resolved independently for each conjunct: the type of *się* is specified by the lexical entry of the verb; it is inherent (INH) in the first conjunct, while in the second it is reflexive (REFL), as shown in (202).

The analysis of Patejuk & Przepiórkowski (2015) could be used for German SGF: while the c-structure would be different, the corresponding f-structure would be the same.

Apart from the analysis of shared *się*, there is one more situation which clearly distinguishes between the effects of the analysis of Patejuk & Przepiórkowski (2015) and an SGF-like analysis: when a shared dependent displays case syncretism that is disambiguated by predicates requiring different values of case, as in the following example:

(203) Polish
[[Marysia lubi Janka]], a [Zosia nienawidzi]].
Marysia.NOM likes Janek.ACC/GEN and Zosia.NOM hates
'Marysia likes Janek, while Zosia hates him.'

In this example, the first verb (*lubi* 'likes') requires an accusative object (in the absence of sentential negation), while the second verb (*nienawidzi* 'hates') requires a genitive object – the form *Janka* is syncretic between accusative and genitive, so it can be used as the object of both predicates, despite their different case requirements.

Except for word order, (203) is analogous to (204) (originally from Dyła (1984)):

(204) Polish
Kogo [[Janek lubi] a [Jerzy nienawidzi]]?
who.ACC/GEN Janek.NOM likes and Jerzy.NOM hates
'Who does Janek like and Jerzy hate?' (Dalrymple et al. 2009: (10))

Dalrymple et al. (2009) offer an analysis of (204) which involves a complex CASE attribute (instead of atomic values used so far for CASE), making it possible to account for case syncretism and feature indeterminacy. The lexical entry of the noun *kogo* (the same applies to *Janka* in (203)) contains a disjunctive specification of case: (↑ CASE {ACC|GEN}) = +, while lexical entries of verbs assign appropriate values of case to their object: (↑ OBJ CASE ACC) = + for *lubi* (when there is no sentential negation) and (↑ OBJ CASE GEN) = + for *nienawidzi*. Under such an analysis, the f-structure in (205) corresponds to (204).[46]

(205)
$$\left[\begin{array}{l} \left\{ \left[\begin{array}{ll} \textsc{pred} & \text{`like}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \textsc{subj} & \boxed{1}\left[\begin{array}{ll} \textsc{pred} & \text{`Janek'} \\ \textsc{case} & \textsc{nom} \end{array}\right] \\ \textsc{obj} & \boxed{2}\left[\begin{array}{ll} \textsc{pred} & \text{`who'} \\ \textsc{case} & \left[\textsc{acc}\ +\right] \end{array}\right] \end{array}\right], \left[\begin{array}{ll} \textsc{pred} & \text{`hate}\langle\boxed{3},\boxed{4}\rangle\text{'} \\ \textsc{subj} & \boxed{3}\left[\begin{array}{ll} \textsc{pred} & \text{`Jerzy'} \\ \textsc{case} & \textsc{nom} \end{array}\right] \\ \textsc{obj} & \boxed{4}\left[\begin{array}{ll} \textsc{pred} & \text{`who'} \\ \textsc{case} & \left[\textsc{gen}\ +\right] \end{array}\right] \end{array}\right] \right\} \\ \textsc{conj} \quad \textsc{and} \end{array}\right]$$

Coming back to (203): under an SGF-like analysis the accusative object of the first conjunct is distributed over the entire coordination, so the object of the first conjunct would be marked for accusative case, while the object of the second conjunct would be marked for accusative and genitive case – this is undesired. By contrast, under the account of Patejuk & Przepiórkowski (2015) case is assigned independently in each conjunct (rather than being copied from the first conjunct), so the f-structure representation of (203) would be analogous to (205): the object of the first conjunct would only be marked for accusative case, while the object of the second conjunct would only bear genitive case.

5.3 Gapping

Gapping is a variety of clause-level coordination where certain elements of the first conjunct (the non-gapped conjunct, the conjunct without a gap) are shared (marked with underline) with the second conjunct (the gapped conjunct, the conjunct with some gap(s)). Minimally the main verb is shared, as in (206), but some of its dependents may also be shared, as in (207) where the direct object (*an apple*) is also shared.

(206) [[Marge gave an apple to Lisa], and [Homer a donut to Bart]].
(Patejuk & Przepiórkowski 2017: (1))

[46]In Dalrymple et al. (2009) NPs lexically specify impossible values of CASE as −. To save space, these attribute-value pairs are omitted in (205). For OBJ these are: NOM −, DAT −, INST −, LOC −, VOC −.

(207) [[Marge gave an apple to Lisa], and [Homer to Bart]].
(Patejuk & Przepiórkowski 2017: (2))

5.3.1 Basics of the Patejuk & Przepiórkowski (2017) analysis

Patejuk & Przepiórkowski (2017) offer an LFG analysis of gapping which relies on two key features: the set-based representation of coordination and distribution. The material in the first conjunct (the verb and all its dependents) is split into two parts: shared and non-shared. The shared material is distributed over the coordination of non-shared material, namely the set which contains non-shared material from the first conjunct and the partial f-structure produced by dependents in the second conjunct.

The analysis relies on the rules shown in (208)–(211). (208) is the main coordination rule for gapping where IP1 is the non-gapped conjunct (defined in (209)),[47] while IP is the gapped conjunct (see (210)).[48] Each dependent (DEP, see its definition in (211)) of the non-gapped conjunct (IP1) may be shared or not. This is achieved using the annotation (↑ (LOCAL))=↓ on DEP in (209), which resolves to one of two possible annotations: ↑=↓ distributes the DEP over the entire coordination (so that it is shared by all conjuncts: non-gapped and gapped), while (↑ LOCAL)=↓ makes it belong to the non-gapped conjunct only (it is not distributed over coordination in gapping). Finally, each dependent (DEP, in IP1 and IP) is assigned appropriate f-structure annotation (including GF) in (211).

(208) $$\text{IP} \longrightarrow \underset{\substack{\uparrow=\downarrow \\ (\downarrow\ \textsc{local}) \in \uparrow}}{\text{IP1}} \quad [,\ \underset{\downarrow\in\uparrow}{\text{IP}}]^* \quad \text{Conj} \quad \underset{\downarrow\in\uparrow}{\text{IP}}$$

(209) $$\text{IP1} \longrightarrow \underset{(\uparrow\ (\textsc{local})) = \downarrow}{\text{DEP*},} \quad \text{I}$$

(210) $$\text{IP} \longrightarrow [\text{DEP*},\quad (\text{I})] \quad (\text{NEG})$$

(211) $$\text{DEP} \equiv \left\{ \underset{(\uparrow\ \{\textsc{subj}|\textsc{obj}\}) = \downarrow}{\text{NP}} \;\middle|\; \underset{(\uparrow\ \textsc{obl}) = \downarrow}{\text{PP}} \;\middle|\; \underset{(\uparrow\ \textsc{xcomp}) = \downarrow}{\text{InfP}} \;\middle|\; \ldots \right\}$$

Together, these rules give rise to (212) as the f-structure corresponding to (206).

[47] IP1 may contain negation: sentential negation is a prefix in Polish (though it may be separated from the verb by whitespace), so it is part of I. However, negation in the gapped conjunct is not a prefix (there is no verb, it is gapped) and it comes as the last element – this is why (210) contains an extra NEG.

[48] The optional NEG (sentential negation) in (210) is required by Polish examples such as (226).

(212)
$$\left[\begin{array}{l} \left\{ \boxed{0}\left[\begin{array}{lll} \text{PRED} & \multicolumn{2}{l}{\text{`GIVE}\langle\boxed{1},\boxed{2},\boxed{3}\rangle\text{'}} \\ \text{SUBJ} & \boxed{1} & \left[\text{PRED} \ \text{`MARGE'}\right] \\ \text{OBJ} & \boxed{2} & \left[\text{PRED} \ \text{`APPLE'}\right] \\ \text{OBL} & \boxed{3} & \left[\text{PRED} \ \text{`LISA'}\right] \end{array}\right], \left[\begin{array}{lll} \text{PRED} & \multicolumn{2}{l}{\text{`GIVE}\langle\boxed{4},\boxed{5},\boxed{6}\rangle\text{'}} \\ \text{SUBJ} & \boxed{4} & \left[\text{PRED} \ \text{`HOMER'}\right] \\ \text{OBJ} & \boxed{5} & \left[\text{PRED} \ \text{`DONUT'}\right] \\ \text{OBL} & \boxed{6} & \left[\text{PRED} \ \text{`BART'}\right] \end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND} \\ \text{LOCAL} \ \boxed{0} \end{array}\right]$$

(Patejuk & Przepiórkowski 2017: (19))

What follows is a procedural intuition of this analysis, showing how (212) is constructed.

(213) is the partial f-structure corresponding to the first (non-gapped) conjunct, constructed using the rules in (209) and (211). Using (211), each dependent of the first conjunct is assigned an appropriate GF, as shown in (214)–(216): *Marge* is the SUBJ(ect), *an apple* is the OBJ(ect), *to Lisa* is an OBL(ique). According to (209), the main verb is shared (by default, it has the co-head annotation: ↓=↑), while each of its dependents (DEP) may be shared or not. In (206) the annotation of all dependents resolves to (↑ LOCAL)=↓, so they are not shared. This results in the partial f-structure in (213) corresponding to IP1.

(213)
$$\left[\begin{array}{ll} \text{PRED} & \text{`GIVE}\langle\text{SUBJ,OBJ,OBL}\rangle\text{'} \\ \text{LOCAL} \ \boxed{0} & \left[\begin{array}{ll} \text{SUBJ} & \left[\text{PRED} \ \text{`MARGE'}\right] \\ \text{OBJ} & \left[\text{PRED} \ \text{`APPLE'}\right] \\ \text{OBL} & \left[\text{PRED} \ \text{`LISA'}\right] \end{array}\right] \end{array}\right]$$

(214) $\left[\text{SUBJ} \ \left[\text{PRED} \ \text{`MARGE'}\right]\right]$

(215) $\left[\text{OBJ} \ \left[\text{PRED} \ \text{`APPLE'}\right]\right]$

(216) $\left[\text{OBL} \ \left[\text{PRED} \ \text{`LISA'}\right]\right]$

(217) is the partial f-structure corresponding to the second (gapped) conjunct, constructed using the rules in (210) and (211). Using (211), each dependent (DEP) is assigned an appropriate GF, as shown in (218)–(220). According to (210), all dependents (DEP) of the gapped conjunct (IP) have the default co-head annotation, so their partial f-structures are unified, yielding (217) as the partial f-structure corresponding to IP (gapped conjunct).

(217)
$$\left[\begin{array}{ll} \text{SUBJ} & \left[\text{PRED} \ \text{`HOMER'}\right] \\ \text{OBJ} & \left[\text{PRED} \ \text{`DONUT'}\right] \\ \text{OBL} & \left[\text{PRED} \ \text{`BART'}\right] \end{array}\right]$$

(218) $\left[\textsc{subj}\ \left[\textsc{pred}\ \text{‘}\textsc{Homer}\text{’}\right]\right]$

(219) $\left[\textsc{obj}\ \left[\textsc{pred}\ \text{‘}\textsc{donut}\text{’}\right]\right]$

(220) $\left[\textsc{obl}\ \left[\textsc{pred}\ \text{‘}\textsc{Bart}\text{’}\right]\right]$

The final step is to apply the gapping coordination rule in (208). While it does two things at the same time, this will be presented as two separate steps for the sake of exposition. The first effect of (208) is to produce (221) – the partial f-structure corresponding to the coordination of non-shared material from both conjuncts. As a result of the (↓ LOCAL) ∈ ↑ annotation on the non-gapped conjunct (IP1) in (208), the content of its LOCAL attribute is added to the set (see (213) for the f-structure of the non-gapped conjunct); the standard ↓∈↑ annotation on the gapped conjunct (IP) adds its f-structure (see (217)) to the set.

(221) $$\left[\begin{array}{l}\left\{\boxed{0}\left[\begin{array}{ll}\textsc{subj} & \left[\textsc{pred}\ \text{‘}\textsc{Marge}\text{’}\right]\\ \textsc{obj} & \left[\textsc{pred}\ \text{‘}\textsc{apple}\text{’}\right]\\ \textsc{obl} & \left[\textsc{pred}\ \text{‘}\textsc{Lisa}\text{’}\right]\end{array}\right], \left[\begin{array}{ll}\textsc{subj} & \left[\textsc{pred}\ \text{‘}\textsc{Homer}\text{’}\right]\\ \textsc{obj} & \left[\textsc{pred}\ \text{‘}\textsc{donut}\text{’}\right]\\ \textsc{obl} & \left[\textsc{pred}\ \text{‘}\textsc{Bart}\text{’}\right]\end{array}\right]\right\}\\ \textsc{conj}\quad \textsc{and}\end{array}\right]$$

The second effect of (208), resulting from the ↓=↑ annotation on IP1, is to distribute the partial f-structure in (213), corresponding to the shared material from the first conjunct,[49] over the f-structure in (221) which corresponds to the coordination of non-shared material from both conjuncts. The result of this operation is (212): the final f-structure for (206).

5.3.2 Distribution under gapping: Interactions with other phenomena

Patejuk & Przepiórkowski (2017) discuss interactions between the proposed analysis of gapping, which relies on distribution, and other phenomena, including subject-verb agreement, case assignment and unlike category coordination.

Unlike in (206)–(207), where the verb form used in the first conjunct (*gave*) would also be appropriate in the second conjunct (if it was present), there are examples where different agreement features would be required in different conjuncts, as in (222) from Polish, see the corresponding f-structure in (223):

(222) Polish

[49]Apart from the main predicate, this includes the LOCAL attribute – this is the desired result (Section 5.3.2).

[[Lisa lubiła Nelsona], a [Nelson (lubił)
Lisa.NOM.F liked.F Nelson.ACC.M1 and Nelson.NOM.M1 liked.M1
Lisę]].
Lisa.ACC.F
'Lisa liked Nelson and Nelson (liked) Lisa.'
(Patejuk & Przepiórkowski 2017: (28))

(223)
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\left\{\boxed{0}\left[\begin{array}{ll} \text{PRED} & \text{`LIKE}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\begin{array}{ll}\text{PRED} & \text{`LISA'}\\ \text{CASE} & \text{NOM}\\ \text{GEND} & \text{F}\end{array}\right] \\ \text{OBJ} & \boxed{2}\left[\begin{array}{ll}\text{PRED} & \text{`NELSON'}\\ \text{CASE} & \text{ACC}\\ \text{GEND} & \text{M1}\end{array}\right] \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`LIKE}\langle\boxed{3},\boxed{4}\rangle\text{'} \\ \text{SUBJ} & \boxed{3}\left[\begin{array}{ll}\text{PRED} & \text{`NELSON'}\\ \text{CASE} & \text{NOM}\\ \text{GEND} & \text{M1}\end{array}\right] \\ \text{OBJ} & \boxed{4}\left[\begin{array}{ll}\text{PRED} & \text{`LISA'}\\ \text{CASE} & \text{ACC}\\ \text{GEND} & \text{F}\end{array}\right] \end{array}\right]\right\}} \\ \text{CONJ} & \text{AND} \\ \text{LOCAL} & \boxed{0} \end{array}\right]$$
(Patejuk & Przepiórkowski 2017: (29))

The key feature of the analysis presented above is that it distributes the verb from first conjunct over the entire coordination – as a result, all constraints imposed by the verb are distributed. Assuming a standard account of S-V agreement, where it is handled in the lexical entries of verbs (requiring the subject to satisfy certain agreement constraints, as in (224) where the subject must be singular and feminine), such requirements are distributed to each conjunct, so the subject of each conjunct must satisfy these requirements.

(224) $(\uparrow \text{SUBJ NUM}) =_c \text{SG} \wedge (\uparrow \text{SUBJ GEND}) =_c \text{F}$

This is problematic in (222), where the verb *lubiła* 'liked' in the first conjunct requires a singular feminine subject. While *lubiła* is compatible with *Lisa* in the first conjunct, it is not appropriate for *Nelson* in the second (gapped) conjunct. Though *Nelson* is singular, it is masculine – so it would be compatible with the masculine verb form *lubił*.

Patejuk & Przepiórkowski (2017) offer a solution, presenting it as conceptually similar to single conjunct agreement (see Section 1.4), where, instead of agreeing with the entire subject, the verb may agree with a designated conjunct as the agreement target. The proposed solution accounts for potential mismatches in S-V agreement between the first conjunct (without a gap) and the gapped conjunct using the LOCAL attribute, which contains the non-shared material from the first conjunct. (225) below is a modified version of (224).

(225) $[\%\text{s} = (\uparrow \text{SUBJ}) \vee \%\text{s} = (\uparrow \text{LOCAL SUBJ})] \wedge$
$[(\%\text{s NUM}) =_c \text{SG} \wedge (\%\text{s GEND}) =_c \text{F}]$

While (224) uniformly requires the subject to be singular and feminine, (225) has a disjunctive specification of the agreement target (%s). The constraint in (225) is distributed to all conjuncts, where it is resolved independently. When %s resolves to (↑ SUBJ), (225) has the same effect as (224), requiring the subject of the given conjunct to satisfy these constraints – it is not satisfied in the second conjunct of (222). However, when %s resolves to (↑ LOCAL SUBJ) in the second conjunct, the relevant agreement requirements are trivially satisfied, because they are checked against the SUBJ inside the LOCAL attribute (see the f-structure in (223)) – instead of the SUBJ attribute of the given conjunct.

The fact that constraints imposed by the verb are distributed to all conjuncts and resolved independently in each conjunct makes it possible to account for independent case assignment in gapping. Consider (226) with the corresponding f-structure in (227).

(226) Polish

[[Lisa	<u>lubiła</u>	Nelsona],	a	[Nelson	Lisy	nie]].
Lisa.NOM.F	liked.F	Nelson.ACC.M1	but	Nelson.NOM.M1	Lisa.GEN.F	NEG

'Lisa liked Nelson, but Nelson didn't like Lisa.'
(Patejuk & Przepiórkowski 2017: (34))

(227)
$$\left[\begin{array}{l} \left\{ \boxed{0}\left[\begin{array}{ll} \text{PRED} & \text{`LIKE}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\begin{array}{ll}\text{PRED} & \text{`LISA'}\\ \text{CASE} & \text{NOM}\\ \text{GEND} & \text{F}\end{array}\right] \\ \text{OBJ} & \boxed{2}\left[\begin{array}{ll}\text{PRED} & \text{`NELSON'}\\ \text{CASE} & \text{ACC}\\ \text{GEND} & \text{M1}\end{array}\right] \end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{`LIKE}\langle\boxed{3},\boxed{4}\rangle\text{'} \\ \text{SUBJ} & \boxed{3}\left[\begin{array}{ll}\text{PRED} & \text{`NELSON'}\\ \text{CASE} & \text{NOM}\\ \text{GEND} & \text{M1}\end{array}\right] \\ \text{OBJ} & \boxed{4}\left[\begin{array}{ll}\text{PRED} & \text{`LISA'}\\ \text{CASE} & \text{GEN}\\ \text{GEND} & \text{F}\end{array}\right] \\ \text{NEG} & + \end{array}\right] \right\} \\ \text{CONJ} \quad \text{AND} \\ \text{LOCAL} \quad \boxed{0} \end{array}\right]$$

(Patejuk & Przepiórkowski 2017: (35))

As mentioned earlier (see Section 3.5.1), simplifying, in Polish objects marked for structural case are required to bear accusative case in the absence of sentential negation, while genitive case is required if negation is present. In (226) the object of the first conjunct is accusative due to the lack of negation, while the object of the gapped conjunct is genitive because negation is present there. The relevant disjunctive case constraint is evaluated independently in each conjunct, leading to the f-structure representation in (227).

There is another interesting consequence of the fact that disjunctive constraints imposed by the verb are distributed across coordination under gapping. If a given verb allows for coordination of different categories – for instance, its object may correspond to an NP or a CP, as in (228) – then the object of the first conjunct may be an NP, while the object of the gapped conjunct may be a CP, as in (229), whose f-structure is given in (230).

(228) Polish
Lisa chciała [[książkę] i [żeby ktoś ją
Lisa.NOM wanted book.ACC and that somebody.NOM she.ACC
przytulił]].
hug
'Lisa wanted a book and that somebody hug her.'
(Patejuk & Przepiórkowski 2017: (38))

(229) Polish
[[Lisa <u>chciała</u> książkę], a [Maggie żeby ktoś
Lisa.NOM wanted book.ACC and Maggie.NOM that somebody.NOM
ją przytulił]].
she.ACC hug
'Lisa wanted a book and Maggie wanted someone to hug her.'
(Patejuk & Przepiórkowski 2017: (39))

(230)
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\left\{ \boxed{0}\left[\begin{array}{ll} \text{PRED} & \text{'WANT}\langle\boxed{1},\boxed{2}\rangle\text{'} \\ \text{SUBJ} & \boxed{1}\left[\begin{array}{ll}\text{PRED} & \text{'LISA'}\\ \text{CASE} & \text{NOM}\end{array}\right] \\ \text{OBJ} & \boxed{2}\left[\begin{array}{ll}\text{PRED} & \text{'BOOK'}\\ \text{CASE} & \text{ACC}\end{array}\right]\end{array}\right], \left[\begin{array}{ll} \text{PRED} & \text{'WANT}\langle\boxed{3},\boxed{4}\rangle\text{'} \\ \text{SUBJ} & \boxed{3}\left[\begin{array}{ll}\text{PRED} & \text{'MAGGIE'}\\ \text{CASE} & \text{NOM}\end{array}\right] \\ \text{OBJ} & \boxed{4}\left[\begin{array}{ll} \text{PRED} & \text{'HUG}\langle\boxed{5},\boxed{6}\rangle\text{'} \\ \text{SUBJ} & \boxed{5}\left[\begin{array}{ll}\text{PRED} & \text{'SB'}\\ \text{CASE} & \text{NOM}\end{array}\right] \\ \text{OBJ} & \boxed{6}\left[\begin{array}{ll}\text{PRED} & \text{'SHE'}\\ \text{CASE} & \text{ACC}\end{array}\right] \\ \text{COMP-FORM} & \text{THAT}\end{array}\right]\end{array}\right] \right\}} \\ \text{CONJ} & \text{AND} \\ \text{LOCAL} & \boxed{0}\end{array}\right]$$
(Patejuk & Przepiórkowski 2017: (41))

6 Conclusion

On the basis of various phenomena, this chapter discussed the possibilities created by the two key concepts related to coordination in LFG: the set-based representation (conjuncts are elements of a set) and distribution whose effects are important at two levels (attributes vs. properties). The distinction between distributive and non-distributive attributes is crucial not only for phenomena related to agreement (including feature resolution), it also makes it possible to share parts of f-structure (enabling dependent sharing). This chapter also discussed distribution at the level of properties (complex statements), showing that it is necessary to account for disjunctive subcategorisation constraints in coordination, which include not only category, but also features such as CASE, preposition/complementiser form, etc.

Apart from run-of-the-mill coordination, this chapter presented a range of more challenging coordination phenomena, including non-constituent coordination (NCC), coordination of unlike categories, coordination of different grammatical functions (showing the difference between monoclausal and multiclausal representation) and phenomena associated with ellipsis such as German SGF, sharing intertwined dependents and gapping. Selected interactions between these phenomena have also been discussed.

Despite its considerable size, this chapter could only discuss a selection of topics related to coordination. Feature resolution was only mentioned very briefly, on the assumption that it is more closely related to agreement than coordination. A key issue which has not been touched upon here is the semantics of coordination. Dalrymple et al. (2019: Chapter 16) is an excellent chapter devoted to coordination in LFG (with a different selection of phenomena, providing rich references) which extensively covers these two topics. It is remarkable in that it includes semantics as its key component, together with a formalisation in Glue.

Abbreviations

Besides the abbreviations from the Leipzig Glossing Conventions, this chapter uses the following abbreviations.

M1	human masculine (virile) gender
M3	inanimate masculine gender
PRT	particle
INH	inherent

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Chapter 4

Unbounded dependencies

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Grammatical representations and the operations defined on them are designed to take advantage of the fact that most syntactic dependencies (such as agreement, government, and control) are local. Typically they can be defined on string-adjacent elements or on elements that can be made tree-adjacent with hierarchical structures of modest and definite depth. It is also well known, however, that languages exhibit some phenomena that require the capability to describe syntactic relations that hold over wider domains. With such unbounded dependencies a grammatical function assigned within an embedded clause is correlated with a configuration of items that appear elsewhere in the sentence and perhaps far away from the other words and phrases that make up that clause. This is a characteristic pattern in particular of topicalization, constituent questions, relative clauses, and *tough*-adjective constructions.

The earliest LFG approaches to unbounded dependencies were modeled after the phrase structure solutions of other frameworks, but it is now generally recognized that the functional configurations enshrined in f-structure support the simplest descriptions and explanations. This chapter surveys many of the theoretical and empirical issues that have been discussed in the LFG literature and in the linguistic literature more broadly. Unbounded dependencies interact in complicated ways with the syntactic properties that define the local organization of clauses and sentences. Within LFG, functional uncertainty combines with off-path annotations to offer the most natural and direct accounts of these complex interactions. These technical devices integrate well with other aspects of the LFG formalism.

There is a substantial literature that aims to identify principles that apply broadly, if not universally, to condition the appearance of unbounded dependencies and also to identify the dimensions of variability across constructions and languages. This chapter surveys just some of the major descriptive and theoretical challenges that these dependencies have presented and sketches how

Ronald M. Kaplan & Annie Zaenen. Forthcoming. Long-distance dependencies. In Mary Dalrymple (ed.), *Handbook of Lexical Functional Grammar*. Berlin: Language Science Press.

they have been, or in some cases might be, addressed with the tools and techniques of Lexical Functional Grammar. Section 1 sets the stage for this discussion with some simple examples of the topicalization construction. These show that a phrase at the front of a sentence is interpreted as an argument of a distant predicate and its syntactic features are governed by that predicate. Kaplan & Bresnan (1982) proposed an LFG account of unbounded dependencies based on the categories and dominance relations of c-structure. Section 2 outlines that original proposal but then summarizes the considerations that led Kaplan & Zaenen (1989) to conclude that these dependencies are better described in functional terms, as instances of "functional uncertainty". Functional uncertainty is a straightforward extension to the notation of functional descriptions and has now become the standard mechanism for characterizing unbounded dependencies in LFG grammars.

English constituent questions (Section 3) are slightly more complicated than topicalizations because of the additional requirement that an interrogative pronoun exists at an uncertain position inside the initial question phrase. In traditional treatments the topicalized and question phrases correspond to the values of distinguished f-structure attributes, TOPIC and FOCUS respectively, that serve as signals for the discourse entailments of these constructions. It has been argued that those entailments properly belong to a separate component of grammar, Information Structure (Zaenen forthcoming [this volume]), and this suggests (Section 4) removing such grammaticized discourse functions from f-structure in favor of explicit mappings to i-structure made possible by LFG's Correspondence Architecture.

The English *tough* construction (Section 5) is of interest because its unbounded dependency is introduced by an annotation in a lexical entry rather than a c-structure rule, and also because the shared f-structure element is governed by predicates in two different clauses. This may lead to a so-called "connectivity problem" wherein a sentence is grammatical even though the two clauses assign incompatible values to some features, CASE in particular. This section outlines several solutions to that problem, should it arise. Connectivity is also a potential issue for relative clauses, since as in the *tough* construction the relativized NP appears to play a role in two clauses. Relative clauses have the additional complexity, like constituent questions, that an initial topic phrase must contain a relative pronoun at some uncertain position. Relative clauses are discussed in Section 6.

Section 7 covers a collection of constraints that may be layered on top of the basic constructions previously described. For some constructions in some languages the form of a clause may change if a dependency passes through it.

Some clauses and some configurations are impervious to unbounded dependencies, forming what are traditionally known as islands. And there are also linear order constraints that seem to tie the functionally-specified unbounded dependencies more closely to the sequence of words in the sentence. The last section discusses possible LFG accounts for parasitic gaps and other multiple gap constructions, a dependency pattern that is unexpected and problematic for almost every grammatical theory.

1 Topicalization: A simple unbounded dependency

Typical examples of unbounded dependencies are topicalization, constituent questions, and relative clauses in English and other languages. What is important in these constructions is that an element in a matrix clause bears a grammatical function governed by the verb in a clause that may be arbitrarily far away in the sentence. This is exemplified by the topicalization in (1).

(1) Mary, John claimed that Bill said that Henry called.

In (1), *Mary* is understood as the object of *called* but it occurs outside the embedded clause that contains that verbal predicate. Hence local functional equations are not able to describe the dependency nor can it be inferred from the local c-structure hierarchy. Without further specification the embedded f-structure will be incomplete. Of course the grammar can include a local functional dependency with a long sequence of attributes to share information between the higher and lower clauses in this particular sentence. But the hallmark of dependencies of this type is that they tend to be unbounded in the sense that the embedding structure can be arbitrarily deep, as the following variant of (1) suggests:

(2) Mary, John claimed that Bill said that Henry expected to call.

There is little morphological marking on the elements of English topicalization. But in other languages it is very clear that the external item must have the markings that go along with the clause-internal grammatical function to which it is assigned. The following German example is an illustration of such a correlation:

(3) German (Berman 2003)

Den	Peter	glaube	ich	hat	die	Maria	eingeladen
the.ACC	Peter	believe	I	has	the	Maria	invited

'Peter, I think that Maria has invited.'

Here *den Peter* is in the accusative because *einladen* 'invite' takes an accusative object. Case marking is not the only connectivity effect. Reflexivization constraints also register the external element as fulfilling a function in the embedded f-structure, as shown in the following Icelandic example:

(4) Icelandic
Sjálfum sér held ég ekki åð Jón geðjist.
Himself think I not that John likes.
'I don't think that John likes himself.'

In Icelandic, elements that are coreferent with the subject of their clause need to take a reflexive form (*sjálfum* in this example) that is distinct from a nonreflexive pronoun (*hann*). This requirement must be satisfied even when the subject is realized outside of the clause.

As a first approximation, the obvious way to handle such interactions is through the kind of structure sharing that is used in LFG descriptions of raising constructions (Vincent forthcoming [this volume]). There it is also the case that an f-structure element plays two roles, e.g. subject of a lower clause and object of a higher one. What is different in the case of unbounded dependencies is the fact that the inventory of possible f-structure paths between higher and lower elements cannot in principle be characterized by finite sequences of intermediate functions.

2 LFG formalizations

LFG has two types of syntactic representations and it is not clear *a priori* whether unbounded dependencies should be modeled in the c-structure or in the f-structure.

2.1 Early approach based on c-structure

In Kaplan & Bresnan (1982) unbounded dependencies were modeled via the c-structure spine as in many other frameworks of that period. The representation for sentence (1) is shown in Figure 1.[1]

[1]The nodes in this c-structure are labeled with modern X′ categories instead of the traditional categories found in earlier LFG papers (e.g. Kaplan & Bresnan 1982, Kaplan & Zaenen 1989). But I depart from common X′ assumptions in showing c-structures that are not cluttered with nodes that are nonbranching, nonmajor, nonlexical, and functionally transparent (annotated with ↑=↓). Other categories (like C′ and VP′) can appear as macro arguments, phantom categories, or metacategories in c-structure grammar specifications (Kaplan & Maxwell 1996,

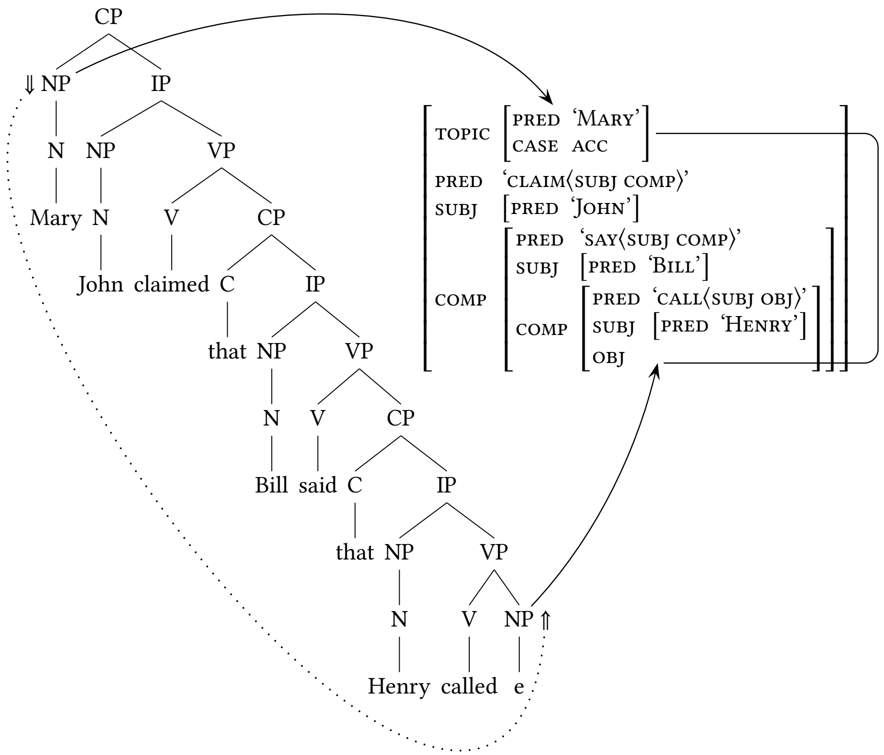


Figure 1: Long-distance relation in c-structure induces f-structure sharing for sentence (1), following Kaplan & Bresnan (1982).

In this formulation the linkage between the clause-external item and its clause-internal function is specified by the c-structure rules in (5). This analysis depends on the fact that the OBJ function is assigned to an NP under VP (5c) and that any NP can expand to an empty "trace" node, indicated by e in (5b).

(5) a. CP ⟶ NP IP
   (↑ TOPIC)=↓ ↑=↓
   ↓=⇓

b. NP ⟶ e
   ↑=⇑

Crouch et al. 2011) and thus can still be used to express generalizations over the context-free rules that describe well-formed c-structures. In that regard they have the same explanatory value as the names and arguments of the f-structure templates discussed by Dalrymple et al. (2004). These reduced c-structures are compatible with Bresnan's (2001) notion of economy and with Lovestrand & Lowe's (2017) theory of minimal phrase structure.

c. $\text{VP} \longrightarrow \underset{\uparrow=\downarrow}{\text{V}} \quad \underset{\substack{(\uparrow \textsc{obj})=\downarrow \\ (\downarrow \textsc{case})=\textsc{acc}}}{\text{NP}}$

The double arrows ⇑ and ⇓ are metavariables, like ↑ and ↓, that denote the f-structures corresponding to c-structure nodes in particular configurations. In the annotations on a daughter category in a given rule, ↑ refers to the f-structure corresponding to the mother node, and ↓ refers to the f-structure corresponding to the daughter. In contrast, the double arrows (called "bounded-domination metavariables") match nodes that are separated in the c-structure but are related through a longer dominance path. Thus the NP in front is a sister of a clause that contains the trace node, and the dominance path between the nodes is allowed because it does not contain other nodes that encode so-called island constraints (see Section 7.2). The dotted line in Figure 1 connects the two c-structure nodes with matching double arrows. The c-structure-to-f-structure correspondence then induces the sharing relationship depicted in the f-structure. The TOPIC function records the special significance of the external constituent as a place-holder for subsequent interpretation by other components of grammar, but it is not here involved in establishing the syntactic connection; Section 4 revisits the grammatical status of the so-called discourse attributes TOPIC and FOCUS.

In this example the nodes that are linked by the double-arrows are both labeled by the same c-structure category NP, but this is not a necessary property of the topicalization construction. Indeed, Kaplan & Bresnan (1982) noted that in some cases instead the nodes are required to have categories that mismatch, as illustrated in (6). Examples (6a-b) show that a CP complement can appear within a clause immediately after *think* but not after *think of*. In contrast, a CP complement in topicalized position is acceptable only when it is linked to the canonical NP position after *of* (6c-d).

(6) a. He didn't think that he might be wrong.
b. * He didn't think of that he might be wrong.
c. * That he might be wrong he didn't think.
d. That he might be wrong he didn't think of.

In the face of examples such as these, Kaplan & Bresnan (1982) embellished their node-linking notation to enable a more intricate relationships of nodes and categories.

It became apparent through subsequent research, however, that constraints on unbounded dependencies are generally more sensitive to functional rather than to c-structure properties. Kaplan & Zaenen (1989) point out that in Icelandic, for example, binding into comps is possible but binding into adjunct clauses is restricted, even when these two types of embeddings have similar c-structures. They consider the following sentences:

(7) Icelandic

a. Jón var að þvo golfið efter að María hafði skrifað brefið.
John was at wash floor.the after that Maria had written letter.the
'John was washing the floor after Maria had written the letter.'

b. þu vonaðist til að hann fengi bill.
You hoped for that he will.get car
'You hoped that he would get a car.'

They argue that both embedded clauses are introduced with a PP that is the c-structure sister of the main verb, but the f-structures for these sentences are different. In the first example the embedded clause is not an argument of the main verb whereas in the second one it is. This difference correlates with the binding contrast illustrated in (8).

(8) Icelandic

a. *Þessi bréf var Jón að þvo golfið efter að María hafði skrifað.
this letter was John at wash floor.the after that Maria had written
'This letter, John was washing the floor after Maria had written.'

b. Hvaða bíl vonaðist þu til að hann fengi.
Which car hoped you for that he will.get
'Which car did you hope that he would get?'

These Icelandic contrasts and the English examples (6) together suggest that the constraints on unbounded dependencies cannot easily be stated in terms of c-structure categories and configurations. In both cases a more natural account can be formulated in terms of functional properties, the difference between arguments and adjuncts, in the Icelandic case, and the restriction against the comp function with the predicate *think* in the English case.

In general, unbounded dependencies are acceptable only if they assign clause internal functions that satisfy the subcategorization requirements of the embedded predicates. The topicalization example (1) is grammatical because the predicate *call* subcategorizes for the function obj; the putative topicalization (9c) is ungrammatical because *arrive* is intransitive.

(9) a. I think Henry will call Mary.
b. * I think Henry will arrive Mary.
c. * Mary I think Henry will arrive.

The fact that subcategorization in LFG is defined at the level of f-structure via the Completeness and Coherence Conditions provided strong motivation for investigating a functional approach to unbounded dependencies.

Additional motivation comes from the fact that unbounded dependencies resemble more local dependencies in the way that they interact with coordinate structures. Sentence (10a) is grammatical because *dedicate* subcategorizes for both an OBJ and an oblique function OBL_θ while (10b) is unacceptable because *bake* does not subcategorize for OBL_θ. Grammatical functions in LFG distribute to all of the conjuncts of a coordination set (Bresnan et al. 1985, Kaplan & Maxwell 1988b, Dalrymple & Kaplan 2000,Patejuk forthcoming [this volume]), and thus the coordination (10c) fails Coherence just as in the uncoordinated case. The topicalization (10d) is also ungrammatical, and the simplest explanation is that the within-clause function of the external phrase is distributed in the ordinary way across both predicates.

(10) a. John dedicated a pie to Bill.
b. * John baked a pie to Bill.
c. * John dedicated and baked a pie to Bill.
d. * To Bill, John dedicated and baked a pie.

2.2 Uncertainty of function assignments

Based on these considerations, Kaplan & Zaenen (1989) developed an approach that refers mainly to f-structure notions to characterize the nature of unbounded dependencies. The f-structure sharing induced by the domination metavariables for the particular example in Figure 1 can be specified directly by the f-description annotation in the alternative rule (11a). This is true even if a c-structure rule such as (5b) is not used to provide a trace NP. Instead, a traceless c-structure configuration is licensed by the alternative VP rule (11b), independently needed for the analysis of clauses with intransitive verbs.

(11) a. $$\text{CP} \longrightarrow \underset{\substack{(\uparrow \text{TOPIC}) = \downarrow \\ (\uparrow \text{COMP COMP OBJ}) = \downarrow}}{\text{NP}} \quad \underset{\uparrow = \downarrow}{\text{IP}}$$

b. $$\text{VP} \longrightarrow \underset{\uparrow = \downarrow}{\text{V}}$$

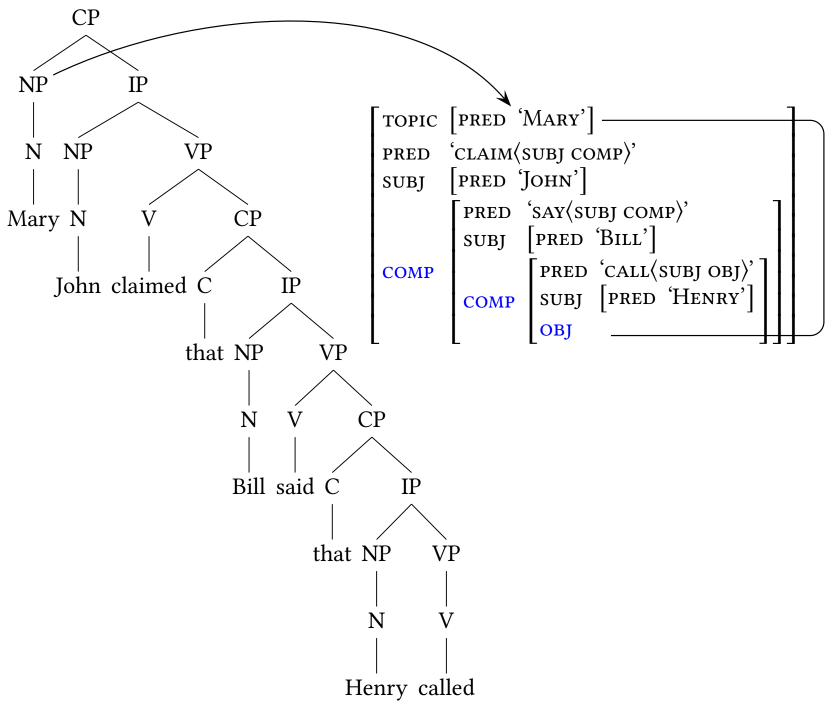


Figure 2: Unbounded relation for sentence (1) defined directly in f-structure via the path of blue attributes (after Kaplan & Zaenen 1989).

The grammatical functions on the longer path in (11a) match the blue attributes in the f-structure in Figure 2 and thus establish the intended link for sentence (1).

For the dependency in sentence (2), however, a longer equation with an additional XCOMP is required, and it is not clear at the position of the topic NP which of the two equations should be chosen to fit the f-structure embeddings of the following clause. In fact, since there is no bound in principle on the depth of an unbounded dependency, there would be infinitely many equations to choose from to account for all possible linkages to the within-clause function of the external NP.

Kaplan & Zaenen (1989) addressed the unbounded uncertainty of the within-clause function assignment by extending the notation and interpretation of LFG's functional descriptions. Kaplan & Bresnan (1982) introduced the basic format and satisfaction condition for function-application expressions of single attributes in (12a) and for notational convenience provided the left-associative extension to a path of attributes in (12b), with (12c) defining the base case of an empty string.

Condition (12d) is satisfied by members of a set of f-structure elements, and the later addition (12e) is the foundation for LFG's distributive theory of coordination, as illustrated in (10) above.

(12) Satisfaction conditions for attributes

a. $(f\ a) = v$ iff f is an f-structure, a is an attribute and $\langle a, v\rangle \in f$.

b. $(f\ a\sigma) = v$ iff $a\sigma$ is a string of attributes and $((f\ a)\ \sigma) = v$.

c. $(f\ e) = v$ iff $f = v$ (e denotes the empty string).

Satisfaction conditions for sets

d. $v \in f$ iff f is a set and v belongs to f.

e. $(f\ a) = v$ iff f is a set and
$(g\ a) = v$ for all $g \in f$ if a is a distributive attribute
$\langle a, v\rangle \in f$ if a is a nondistributive attribute.

Kaplan & Zaenen (1989) first generalized from the single-string specification (12b) to sets of attribute strings as in (13a).

(13) Functional uncertainty

a. If Paths is a set of attribute strings,
$(f\ \textsc{Paths}) = v$ iff $((f\ a)\ \mathit{Suff}(a, \textsc{Paths})) = v$, where
$\mathit{Suff}(a, \textsc{Paths}) = \{\sigma \mid a\sigma \in \textsc{Paths}\}$.
(the suffixes of strings in Paths that begin with attribute a)

b. $(f\ \in) = v$ iff $v \in f$ for the special "attribute" $\in$.

The uncertainty about which paths might result in complete and coherent within-clause function assignments is represented under this formulation by the choice between alternative strings in such a path language. A language containing at least the strings comp comp obj and comp comp xcomp obj, for example, would account for both topicalization sentences (1–2). According to (13b), if the special attribute $\in$ on a path coincides with a set of f-structures, the path can continue through any one of the set's freely chosen elements.

A finite enumeration of path-strings is in essence only a succinct way of specifying a finite disjunction; it would not yet express the unbounded nature of these dependencies. But Kaplan & Zaenen (1989) went further and allowed path-sets to be regular languages containing possibly an infinite number of strings. Such languages can be specified as regular expressions that appear in the annotations in rules and lexical entries. Rule (14) extends the particular annotation in rule (11) to account not only for examples (1–2) but also for topicalizations with comp embeddings of arbitrary depth.

(14) CP $\longrightarrow$ NP IP
$(\uparrow \text{TOPIC}) = \downarrow$ $\uparrow = \downarrow$
$(\uparrow \text{COMP}^* \text{ OBJ}) = \downarrow$

Each of the infinitely many paths in this uncertainty language begins with some number of COMPs, what Kaplan and Zaenen called the "body", and finally ends in OBJ (the "bottom"). Rule (15) covers a larger set of English topicalization patterns by relaxing the category of the external phrase and enlarging the set of paths in the uncertainty language.[2]

(15) CP $\longrightarrow$ XP IP
$(\uparrow \text{TOPIC}) = \downarrow$ $\uparrow = \downarrow$
$(\uparrow \text{TopicPaths}) = \downarrow$
where TopicPaths is $\{\text{COMP}, \text{XCOMP}, \text{ADJ} (\in)\}^* [\text{GF} - \text{COMP}]$

As discussed by Kaplan and Zaenen, CP is a possible realization for the generic XP category in this rule and thus provides the c-structures for the topicalized complements of *think* in (6c–6d). The relative-difference [GF−COMP] at the bottom of every uncertainty path disallows COMP but includes OBJ, SUBJ, OBL_θ, ADJ, and every other function. The short, bottom-only path-string COMP is thus not available for the inadmissible example (6c). Adding XCOMP to the body of this expression allows for the bottom function to be embedded under a mixture of tensed and infinitival complements. Given (13b), the ADJ and $\in$ options provide an analysis for the English sentences (16) (examples from Dalrymple 2001); presumably ADJ would not appear in the language of Icelandic paths.

(16) a. Julius teaches his class in this room.
b. This room Julius teaches his class in.
c. In this room Julius teaches his class.

Further extensions and restrictions on the TopicPaths and other path language are discussed in later sections.

[2] In movement-based frameworks the clause-external c-structure phrase in topicalization and other constructions is often referred to as the "filler" of the dependency and the string position of a putative trace node is known as the "gap". That conventional terminology translates to the LFG functional account with the proviso that the filler refers not to the external phrase but to its corresponding f-structure, and the gap is the within-clause function assignment of that f-structure. The canonical string position for the gap function (or the position of the empty node in a trace-based analysis) is often marked by an underscore, just as a reader's guide to the intended interpretation.

Functional uncertainty has become the primary technical device for describing unbounded dependencies in LFG. Uncertainty languages can be defined by the primitive regular-expression operators of concatenation, union (curly braces), optionality (parentheses), and Kleene-star and Kleene-plus repetition. Indeed, since the regular languages are closed under intersection and complementation, a collection of attribute paths can be specified by any Boolean combination of the same regular predicates that are allowed in the right sides of LFG c-structure rules (see Kaplan & Maxwell 1996, Crouch et al. 2011). This includes the relative difference operator [GF−COMP] above and its equivalent but more succinct term-complement predicate \COMP. Path languages that describe a wide range of constructions in different languages can thus be expressed as the composition of separate, simpler formulas that encode independent linguistic generalizations, as illustrated in later sections. Also of importance, it has been shown that the satisfiability of functional descriptions remains decidable when the LFG formalism is extended with regular path languages (e.g. Kaplan & Maxwell 1988a, Backofen 1993).

3 Constituent questions

Constituent questions in English resemble topicalization in that the f-structure of a clause-external phrase is assigned a grammatical function at some level inside its sister clause. The possibilities for the dependency path between the filler and its within-clause function are similar, but there is an additional requirement that the filler either must be an interrogative (*wh*) pronoun or must contain one. The examples of indirect questions in (17) illustrate some of the possibilities.

(17) I wonder …
  a. who John thinks Henry will call.
  b. which lawyer John thinks Henry will call.
  c. whose friend John thinks Henry will call.
  d. whose lawyer's friend John thinks Henry will call.
  e. from whom John thinks Mary will get a call.
  f. when John will call Mary.
  g. * this lawyer John thinks Henry will call.
  h. * he John thinks Henry will call.

Kaplan & Bresnan (1982) proposed the attribute FOCUS (distinct from the topicalization attribute TOPIC) as a place-holder for the communicative entailments of the question construction, and a separate attribute Q to place the interrogative pronoun in a canonical position for later interpretation. An f-structure configuration with these attributes for the embedded question in (17b) is shown in (18).

(18)
$$\left[\begin{array}{ll}
\text{FOCUS} & \left\{\left[\begin{array}{ll}\text{PRED} & \text{‘LAWYER’}\\ \text{NUM} & \text{PL}\\ \text{SPEC} & \left[\begin{array}{ll}\text{PRED} & \text{‘WHICH’}\\ \text{PRONTYPE} & \text{WH}\end{array}\right]\end{array}\right]\right\}\\
\text{Q} & \\
\text{PRED} & \text{‘THINK}\langle\text{SUBJ COMP}\rangle\text{’}\\
\text{SUBJ} & \left[\text{PRED ‘JOHN’}\right]\\
\text{COMP} & \left[\begin{array}{ll}\text{PRED} & \text{‘CALL}\langle\text{SUBJ OBJ}\rangle\text{’}\\ \text{TENSE} & \text{FUTURE}\\ \text{SUBJ} & \text{‘HENRY’}\\ \text{OBJ} & \end{array}\right]
\end{array}\right]$$

FOCUS is represented here as taking a set of f-structures as its value. It can thus hold the contributions of additional English question words that might appear in situ (19a) or the multiple question words in initial position that other languages might allow (19b).

(19) a. I wonder who John thinks would like to get what.

b. Hungarian (from Mycock 2007)

Ki	ki-t	ki-nek	mutat-ott	be?
who-NOM	who-ACC	who-DAT	introduce-PAST-DEF.3SG	VM

‘Who introduced who to who?’

The f-structure (18) for the embedded question (17b) is assigned by rule (20). The FocusPaths uncertainty resolves to the blue attribute sequence that relates the entire filler f-structure to its within-clause (non-COMP) function, as for topicalization. The green path, taken from WhPaths, establishes Q as an element inside the filler. The intersection with WhPro further ensures that Q is an interrogative pronoun: given the off-path $=_c$ constraint, the f-structure at the end of any WhPaths string is acceptable only if it also includes the feature [PRONTYPE WH]. Off-path annotations are discussed in Section 7.1 and defined there in (57).

(20)
$$\text{CP} \longrightarrow \begin{array}{c}\text{XP}\\ \downarrow\in(\uparrow\ \text{FOCUS})\\ (\uparrow\ \text{FocusPaths})=\downarrow\\ (\uparrow\ \text{Q})=(\downarrow\ \text{WhPaths}\ \&\ \text{WhPro})\end{array} \quad \begin{array}{c}\text{IP}\\ \uparrow=\downarrow\end{array}$$

where FocusPaths is $\{$COMP, XCOMP, ADJ $(\in)\}^*$ \COMP
WhPaths is $\{$SPEC*,OBJ$\}$
WhPro is $\underset{(\rightarrow\ \text{PRONTYPE})=_c\text{WH}}{\text{GF}^*}$

In fuller treatments, of course, the uncertainty languages FocusPaths and WhPaths are supplemented with appropriate configurations of obliques, adjuncts, and other grammatical functions.

The initial phrase of the English c-structure configuration is the probable cause, the trigger, for introducing the FocusPaths uncertainty expression, and this must then resolve to the proper within-clause grammatical function for that focus phrase. In Mandarin interrogative pronouns appear in situ, at the position in the embedded clause where the proper function is assigned by normal clause-level rules. Huang (1993) discusses the following example.

(21) Mandarin
Zhangsan xiwang Lisi gen shei xue yuyanxue?
Zhangsan hope Lisi gen(with) who learn linguistics
'With whom does Zhangsan hope that Lisi will learn linguistics?'

An unbounded uncertainty is not needed here to establish the within-clause function, and indeed there is no natural place in the c-structure to specify a FocusPaths connection as in (20). But Huang notes that the pronoun must still be linked to some enclosing f-structure in order to establish the necessary scope for semantic and discourse interpretation. He proposes to include in the lexical entry of an interrogative pronoun an uncertain path language that resolves to a higher-level f-structure. Along the lines of that proposal, the lexical entry (22) places the interrogative pronoun in the focus set of a clause from which it is accessible through a path in the collection of (Mandarin-specific) FocusPaths.

(22) *shei*: $\uparrow \in ((\text{FocusPaths}\ \uparrow)\ \text{focus})$

This makes use of the formal device of *inside-out function application* (23a), originally introduced by Kaplan (1988) and subsequently extended by Halvorsen & Kaplan (1988) to uncertain path languages (23b).

(23) Inside-out function application

a. $(\sigma\ f) = g$ iff σ is an attribute string and $(g\ \sigma) = f$.
b. $(\text{Paths}\ f) = g$ iff Paths is a set of attribute strings and $(g\ \text{Paths}) = \text{f}$.

In this case also there is an explicit probable cause for the uncertainty, the interrogative lexical entry. In contrast, there is typically no local evidence to trigger the inside-out uncertainties that are attached to empty nodes in trace-based theories of unbounded dependencies (e.g. Bresnan 2001, Bresnan et al. 2016).

4 Grammaticized discourse functions?

Kaplan & Bresnan (1982) introduced the attributes TOPIC and FOCUS to distinguish the fillers of the different unbounded dependency constructions as separate from the establishment of their within-clause grammatical functions. These f-structure attributes were presumed to represent the syntactic features needed for subsequent interpretation by semantic and discourse components of grammar, and they were maintained as "grammaticized discourse functions" in some later work (e.g. Bresnan & Mchombo 1987). Other chapters describe the subsequent development of explicit theories of semantic representation (Asudeh forthcoming [this volume]) and information structure (Zaenen forthcoming [this volume]) and how LFG's Correspondence Architecture (Kaplan 1987, 1995) provides a uniform framework for integrating such independent modules with the core components of syntax. The literature surveyed in those chapters and also Dalrymple et al. (2019) suggest that the entailments of discourse functions like TOPIC and FOCUS can be spelled out in information structure (i-structure) features such as ±NEW and ±PROM(inent) and by other potential i-structure concepts that help in managing how semantic content is transmitted from speaker to hearer.

With respect to the external phrases of topicalization and question formation, if their different discourse entailments can be carried over to i-structure, there may no longer be motivation to mark those with the distinguished TOPIC and FOCUS attributes in f-structure. Thus, to record the external element in either construction, Asudeh (2004, 2012) proposed just one "overlay function" UDF (for "Unbounded Dependency Function"), Alsina (2008) suggested the attribute OP (for "operator"), and Dalrymple et al. (2019) used the attribute DIS (for "dislocated"). Snijders (2015) goes even further, questioning whether the filler f-structure of either construction is needed other than at its within-clause position. This issue was foreshadowed in King's (1997) earlier and more general argument that discourse focus should be represented in the independent information-structure module. If the discourse functions do not interact with other syntactic features and if the i-structure discourse status of the within-clause function can be signaled without them, then the f-structure clutter of these grammaticized functions can be eliminated entirely. In the following, I explore this possibility.

The Correspondence Architecture is designed to encourage theoretical modularity, allowing different components of linguistic description to be organized in their own most natural ways and avoiding the complexity and confusion that comes from mixing conceptually unrelated primitives in a single representation. Dalrymple & Nikolaeva (2011) propose to relate f-structure to i-structure with the correspondence functions diagrammed in (24) (see also Dalrymple et al. 2019).

The projection σ maps from units of f-structure to meaning constructors in semantic structure, and the projection ι maps meaning constructors into correlated properties in information structure.

(24) I-structure correspondences (from Dalrymple & Nikolaeva 2011)

$$\text{c-structure} \xrightarrow{\phi} \text{f-structure} \xrightarrow{\sigma} \text{s-structure} \xrightarrow{\iota} \text{i-structure}$$

Given this arrangement and without involving any special features in f-structure, the composition of projections $\iota \circ \sigma \circ \phi$ can be used to express the fact that the filler in the topicalization construction is interpreted as an i-structure topic.

The abstract interface between the syntactic and information modules, according to this organization, is made explicit in the revision of the topicalization rule (15) shown in (25a). The TOPIC function assignment has been replaced by the invocation of the TOPIC template defined in (25b) (for more on the explanatory value of templates, see the discussion in Dalrymple et al. 2004).

(25) a. $$\text{CP} \longrightarrow \begin{array}{cc} \text{XP} & \text{IP} \\ @(\text{TOPIC} \uparrow \downarrow) & \uparrow = \downarrow \\ (\uparrow \text{TopicPaths}) = \downarrow & \end{array}$$

b. $\text{TOPIC}(\textit{scope topic}) \equiv @(\text{I-Topic } \textit{scope}_{\sigma\iota}\ \textit{topic}_{\sigma\iota})$

The template I-TOPIC is a place-holder for a separate i-structure theory of topic whose details are hidden from the syntactic modules, but substituting the f-structure designators ↑ and ↓ for the template parameters *scope* and *topic* makes clear that the information needed to interpret the topic is carried by the external phrase.[3] The subscript $\sigma\iota$ is the conventional way of notating the composition of projections in LFG annotations. In comparison to the structures shown in Figure 2 for sentence (1), this gives rise to the three-module relationships in (26).

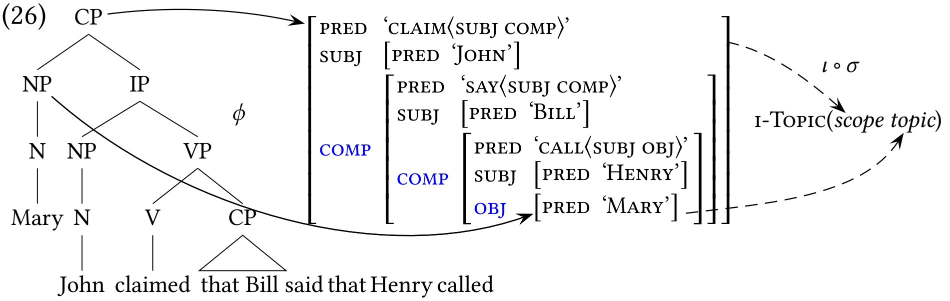
[3]Of course the original f-structure TOPIC attribute, should that be useful, can be easily resurrected by the alternative definition (i).

(i) $\text{TOPIC}(\textit{scope topic}) \equiv (\textit{scope}\ \text{TOPIC}) = \textit{topic}$

(ii) $\text{TOPIC}(\textit{scope topic/focus}) \equiv \textit{topic} \in (\textit{scope}\ \text{DIS})$

Definition (ii) produces the common DIS representation that Dalrymple et al. (2019) specify for both topic and focus. The set value suggests that syntactically the topic is not easily accessible.

(26)



Note that there is no TOPIC and no structure sharing in this f-structure. The filler f-structure appears only at the position of its within-clause function, with the projection lines indicating how the c-structure phrases relate indirectly through the f-structure to the topic in i-structure.

Rule (27a) is a similar revision of the constituent question rule (20). The three-place template FOCUSQ defined in (27b) makes properties of the interrogative pronoun available for i-structure interpretation in addition to information about the focus constituent and its scope.

(27) a. CP $\longrightarrow$ XP IP

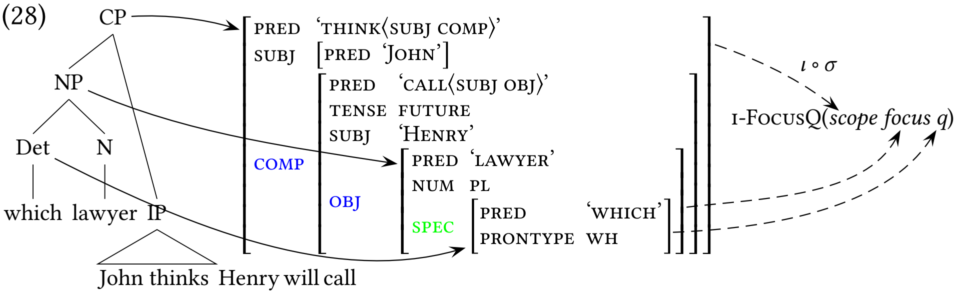
@(FOCUSQ ↑ ↓ (↓ WHPATHS & WHPRO)) ↑=↓

(↑ FOCUSPATHS) = ↓

b. FOCUSQ(*scope focus q*) ≡ @(I-FOCUSQ $scope_{\sigma\iota}$ $focus_{\sigma\iota}$ $q_{\sigma\iota}$)

This results in the relationships shown in (28) for the indirect question (17a).

(28)



There is no set-valued FOCUS attribute and again no structure sharing in this simplified f-structure: the discourse entailments of this construction are off-loaded to the separate i-structure module. This is attractive because it exploits the Correspondence Architecture to simplify syntactic representations, but the full consequences of this arrangement remain to be investigated.

5 The *tough* construction

The English *tough* adjectives (*easy*, *hard*, *difficult*, *impossible*…) induce unbounded dependencies with only one uncertainty, as for topicalization, but they differ from both topicalization and constituent questions in that a single phrase contributes information to grammatical functions that are governed by predicates in two clauses. These adjectives subcategorize for a subject and an open *to*-complement. If the complement has a simple transitive predicate, the adjective's subject is understood as the complement's object and its object must otherwise not be realized. The basic pattern is displayed in (29).

(29) a. Moths seem tough to kill.
(cf. It seems tough to kill moths.)
b. Moths are tough (for someone) to kill.
c. * Moths are tough to kill moths.
d. * Moths are tough to arrive.

It is also generally accepted that the adjective's SUBJ can serve as an OBJ in a clause embedded at an uncertain depth within the immediate complement, as illustrated by the examples in (30).

(30) a. Moths are tough to plan to kill.
b. This book is hard to get her to avoid reading. (Dalrymple & King 2000)
c. Kim would be difficult for me to persuade Robin to attempt to deal with. (Hukari & Levine 1991)
d. Mary is tough for me to believe that John would ever marry. (Kaplan & Bresnan 1982)
e. Kim is difficult to sit next to. (Grover 1995)

This unbounded dependency also differs from topicalization in that the uncertainty is keyed by the lexical entries of adjectives in this particular class rather than by a rule that describes a generic configuration of c-structure phrases. The uncertainty language itself is also quite different. The paths begin with sequences of XCOMPs that do not alternate with COMPs (31a-b), and they end only with OBJ, not just any non-COMP grammatical function (31c-d). The bottom OBJ can be preceded by an oblique (30c), a COMP (30d), or a member of a set of adjuncts (30e).

(31) a. * Mary is tough that John would ever marry.

b. * Mary is difficult for me to believe that John wanted to plan to marry.

c. * Tuesday would be difficult to take the exam. (Dalrymple & King 2000)

d. * Mary is tough for me to believe would ever marry John.

These possibiliites are expressed in the lexical uncertainty shown in (32).

(32) *tough* A $(\uparrow \textsc{pred}) = \text{`}\textsc{tough}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'}$
$(\uparrow \textsc{subj}) = (\uparrow \textsc{xcomp}\ \textsc{ToughPaths})$
where $\textsc{ToughPaths} = \textsc{xcomp}^{*}\ \{\textsc{obl}_{\theta}, \textsc{comp}, \textsc{adj} \in\}\ \textsc{obj}$

This gives rise to the outer connection shown in (33), the f-structure corresponding to sentence (30a) (the inner line indicates the local functional control relation for *plan*).

(33)
$$\left[\begin{array}{ll}
\textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{moth}\text{'} \\ \textsc{num} & \textsc{pl} \\ \textsc{case} & \textsc{nom} \end{array}\right] \\
\textsc{pred} & \text{`}\textsc{tough}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'} \\
\textsc{xcomp} & \left[\begin{array}{ll} \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{`}\textsc{pro}\text{'} \end{array}\right] \\ \textsc{pred} & \text{`}\textsc{plan}\langle\textsc{xcomp}\rangle\textsc{subj}\text{'} \\ \textsc{xcomp} & \left[\begin{array}{ll} \textsc{subj} & \\ \textsc{pred} & \text{`}\textsc{kill}\langle\textsc{subj}\ \textsc{obj}\rangle\text{'} \\ \textsc{obj} & \end{array}\right] \end{array}\right]
\end{array}\right]$$

The *tough* uncertainty establishes an identity between the SUBJ of the adjective and an OBJ somewhere within its complement. The effect is that the predicate and all other f-structure properties of the matrix SUBJ appear also in the embedded OBJ. The examples in (34) suggest that this might lead to inconsistent values for a shared CASE feature.

(34) They/*Them are tough to kill.
It is tough to kill *they/them.

This may have been a weakness for accounts of unbounded dependencies based on empty trace nodes or other properties of c-structure (as in Figure 1), but at least for English it is not an issue under a traceless functional analysis. This is because CASE is assigned to the f-structures of English NPs only by virtue of their appearance in particular c-structure positions. SUBJs of tensed clauses are nominative because they are introduced in an IP rule (35a), and OBJs are marked as accusative when they are realized, for example, in post-verbal NP positions (35b).

(35) a. IP ⟶ NP I′
(↑ SUBJ) = ↓ ↑=↓
(↓ CASE) = NOM

b. VP ⟶ V NP
↑=↓ (↑ OBJ) = ↓
(↓ CASE) = ACC

c. VP ⟶ V
↑=↓

Since rule (35c) is used instead of (35b) to derive the embedded clause of the functionally assigned OBJ, the accusative specification is not introduced into the f-description and there can be no CASE incompatibility with the nominative SUBJ of *tough*.

While not immediately relevant to structural case in the English *tough* construction, the so-called "connectivity problem" has received some attention in the literature (e.g. Hukari & Levine 1991, Dalrymple & King 2000) and raises some technical issues that are still worth discussing. So, for the sake of illustration, suppose a language has an unbounded *tough* construction like English but differs in that CASE is determined idiosyncratically by individual predicates rather than c-structure realization. The lexical entry for *kill* in such a language might have an additional annotation for the CASE of its OBJ (36), and a straightforward functional identity with a *tough* subject now might contribute to an f-structure inconsistency.

(36) English but with lexical case marking
kill V (↑ PRED) = 'KILL⟨SUBJ OBJ⟩'
(↑ OBJ CASE) = ACC

Dalrymple & King (2000) proposed to avoid this problem, should it arise, by removing the functional identity of the two f-structure values. Rather than linking the *tough* SUBJ directly to an embedded OBJ, they depend on an obligatory anaphoric relation between the SUBJ and a grammaticized pronominal TOPIC in *tough*'s immediate complement. It is then the TOPIC f-structure that the uncertainty identifies with an embedded OBJ, as spelled out in (37a).[4] This two-step connection preserves the intended semantic entailments while the appeal to the

[4]Dalrymple & King (2000) assign the function COMP instead of XCOMP to the immediate complement, for reasons that are not relevant to the current discussion. They also argue that the *tough* SUBJ is thematic, but here I follow the raising/non-thematic representation suggested by Kaplan & Bresnan (1982). With respect to the issues of unbounded dependencies, this is also a difference of no consequence.

referential component of grammar suppresses the propagation not only of CASE but also of all other syntactic features. The entry in (37b) achieves the same effect without relying on anaphora or an explicitly grammaticized TOPIC simply by asserting that the SUBJ and the embedded OBJ share only the same uniquely instantiated PRED.[5]

(37) a. *tough* A (↑ PRED) = 'TOUGH⟨XCOMP⟩SUBJ'
(↑ XCOMP TOPIC PRED) = 'PRO'
(↑ XCOMP TOPIC) = (↑ XCOMP ToughPaths)

b. *tough* A (↑ PRED) = 'TOUGH⟨XCOMP⟩SUBJ'
(↑ SUBJ PRED) = (↑ XCOMP ToughPaths PRED)
@(TOPIC (↑ XCOMP) (↑ SUBJ))

The lexical entry (37a) would assign the f-structure (38a) to sentence (29b), with the dashed lines representing an anaphoric relationship. Entry (37b) would assign the f-structure (38b).

(38) a. Anaphoric binding to SUBJ

$$\left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{'MOTH'}\\ \text{NUM} & \text{PL}\\ \text{CASE} & \text{NOM}\end{array}\right]\\ \text{PRED} & \text{'TOUGH}\langle\text{XCOMP}\rangle\text{SUBJ'}\\ \text{XCOMP} & \left[\begin{array}{ll}\text{TOPIC} & \left[\begin{array}{ll}\text{PRED} & \text{'PRO'}\\ \text{CASE} & \text{ACC}\end{array}\right]\\ \text{SUBJ} & \left[\text{PRED} \;\; \text{'PRO'}\right]\\ \text{PRED} & \text{'KILL}\langle\text{SUBJ OBJ}\rangle\text{'}\\ \text{OBJ} & \end{array}\right]\end{array}\right]$$

b. PRED sharing of SUBJ and OBJ

$$\left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{'MOTH'}\\ \text{NUM} & \text{PL}\\ \text{CASE} & \text{NOM}\end{array}\right]\\ \text{PRED} & \text{'TOUGH}\langle\text{XCOMP}\rangle\text{SUBJ'}\\ \text{XCOMP} & \left[\begin{array}{ll}\text{SUBJ} & \left[\text{PRED} \;\; \text{'PRO'}\right]\\ \text{PRED} & \text{'KILL}\langle\text{SUBJ OBJ}\rangle\text{'}\\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \\ \text{CASE} & \text{ACC}\end{array}\right]\end{array}\right]\end{array}\right]$$

Each of these solutions supports the intended semantic interpretation while avoiding the CASE conflict. But each allows for free variation of all other syntactic features, even inherent features like gender or person that may enter into patterns of agreement that CASE does not participate in.

A more precise alternative is based on the restriction operator defined in (39). This permits relaxing the compatibility requirement for specific features (like CASE) while still enforcing consistency of all otherwise unmentioned features.

(39) Definition of restriction: (Kaplan & Wedekind 1993)
If f is an f-structure and a is an attribute, then the restriction of f by a is the f-structure $f\backslash_a = \{\langle s, v\rangle \in f \mid s \neq a\}$.

[5]Since SUBJ is generally assumed to map to a position of i-structure prominence, invoking the TOPIC template in (37b) may not be necessary for proper interpretation.

An f-structure f restricted by an attribute a contains all the attribute-value pairs of f except for the attribute a and its value. This formal device was used by Zaenen & Kaplan (2002) to suppress unwanted CASE conflicts in German functional control. It is applied in (40) to exclude CASE from the unbounded lexical uncertainty that holds between the *tough* SUBJ and the embedded OBJ. That particular incompatibility is thereby eliminated while all other features are shared (and may conflict).

(40) *tough* A (↑ PRED) = 'TOUGH⟨XCOMP⟩SUBJ'
(↑ SUBJ)$\backslash_{\text{CASE}}$ = (↑ XCOMP ToughPaths)$\backslash_{\text{CASE}}$
@(TOPIC (↑ XCOMP) (↑ SUBJ))

The logical f-structure relationships that the CASE restriction induces are shown explicitly in (41):

(41) Functional binding of CASE-restricted SUBJ

$$\left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MOTH'}_i\\ \text{NUM} & \text{PL}\\ \text{CASE} & \text{NOM}\end{array}\right] \\ \text{PRED} & \text{`TOUGH}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{XCOMP} & \left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\end{array}\right] \\ \text{PRED} & \text{`KILL}\langle\text{SUBJ OBJ}\rangle\text{'} \\ \text{OBJ} & \left[\begin{array}{ll}\text{PRED} & \text{`MOTH'}_i\\ \text{NUM} & \text{PL}\\ \text{CASE} & \text{ACC}\end{array}\right]\end{array}\right]\end{array}\right] \quad \sqsupseteq \quad \left[\begin{array}{ll}\text{PRED} & \text{`MOTH'}_i\\ \text{NUM} & \text{PL}\end{array}\right]$$

On the right is the CASE-restricted f-structure that is shared across the functional uncertainty. It subsumes the SUBJ and XCOMP OBJ values, causing them to have all of the same syntactic features except for CASE.

The same logical relations are depicted more intuitively with the abbreviatory graphical convention shown in (42). While the gray brackets in this diagram are not formally part of the linguistic representation, they highlight that the functional identity induced by the restricted unbounded dependency holds only between the enclosed proper subsets of the features of the SUBJ and XCOMP OBJ f-structures.

(42) Functional binding of CASE-restricted SUBJ (succinct)

$$\left[\begin{array}{ll} \text{SUBJ} & \left[\begin{array}{l} \left[\begin{array}{ll}\text{PRED} & \text{`MOTH'}\\ \text{NUM} & \text{PL}\end{array}\right] \\ \text{CASE}\ \ \text{NOM}\end{array}\right] \\ \text{PRED} & \text{`TOUGH}\langle\text{XCOMP}\rangle\text{SUBJ'} \\ \text{XCOMP} & \left[\begin{array}{ll}\text{SUBJ} & \left[\text{PRED}\ \ \text{`PRO'}\right]\\ \text{PRED} & \text{`KILL}\langle\text{SUBJ OBJ}\rangle\text{'} \\ \text{OBJ} & \left[\begin{array}{l}\left[\ \ \right]\\ \text{CASE}\ \ \text{ACC}\end{array}\right]\end{array}\right]\end{array}\right]$$

In sum, the English *tough* construction involves an unbounded connection between two grammatical functions, the SUBJ in the matrix clause and an OBJ embedded in its complement. While this has the potential of incorrectly creating an f-structure conflict between the values of the clause-specific CASE features, that potential is not necessarily realized with a functional account of the dependency. In the straightforward uncertainty analysis the external subject does not correspond to an NP node at an object position in the embedded clause and so there can be no conflict if CASE is assigned only at c-structure nodes. If CASE is assigned in some other way, a direct conflict can be avoided if an anaphoric relationship disrupts the functional identity across the clauses or if only the PRED value is shared. An alternative solution uses the f-structure restriction operator to suppress only the CASE feature without disturbing other patterns of agreement.

6 Relative Clauses

English relative clauses blend the double function assignments of the *tough* construction with the double uncertainties of constituent questions, as exemplified in (43).[6]

(43) The shop [[the owner of which] [Sue knows __]] sells books.

With respect to function assignments, *shop* is understood as both the subject of the matrix predicate *sells* and the (oblique) object of *owner*. With respect to uncertainties, the f-structure of the clause-initial *owner* phrase is the object of *knows* in this example but it could also bind to a function in a deeper complement. And the relative pronoun *which* can also appear at an arbitrary depth inside the

[6]As mentioned earlier, the underscore indicating the position of the 'gap' is provided only as a reader's guide to the intended interpretation. As discussed in Section 7.3, it is quite a separate question whether it should also indicate the presence of an empty node in the syntactic representation.

clause-initial phrase. The examples (44a–44d) of what Ross (1967) called “Pied-piping” show some of the positions possible for the relative pronoun; example (44e) shows that the relative pronoun must appear somewhere.

(44) a. The man who we elected …

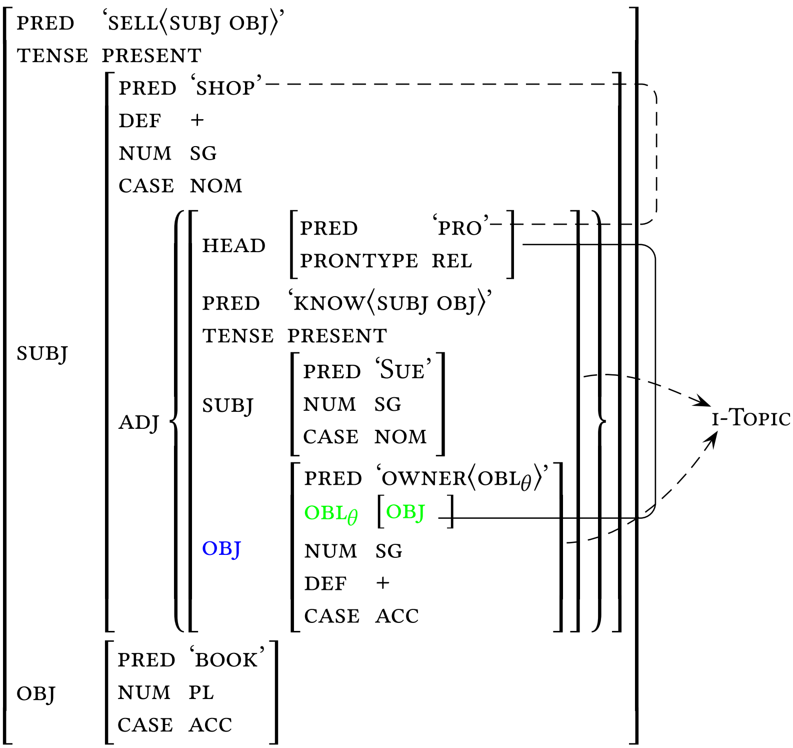
b. The woman to whom we gave the book …

c. The boy whose book Bill said was stolen …

d. Reports the height of the lettering on the covers of which the government prescribes … (Ross 1967)

e. * The shop the owner of the car Sue knows sells books.

F-structure (45) lays out the significant grammatical relationships of sentence (43). The uncertainty of the within-clause function for the clause-initial phrase is resolved by the blue OBJ path in RelTopicPaths, and that phrase also maps to the i-structure topic. The relative pronoun is identified as the HEAD of the clause (the solid line) by virtue of the attributes on the green path from RelHeadPaths. The dashed line between the HEAD and the nominal predicate indicates a connection of obligatory anaphoric control, as in the *tough* f-structure (38a), that avoids any CASE-like inconsistencies that might stem from the double function assignment.

(45)


This f-structure is derived by the rules and lexical entry in (46). According to rule (46a), the f-structure of a single relative clause is added to the adjunct set of the NP; the recursion through the NP category allows for NP's with multiple clauses. Rule (46b) describes the internal structure of the relative clause itself. The f-structure of the clause-initial phrase is linked to its within-clause function through a path in RelTopicPaths and is also projected to the i-structure topic by the topic template. The head at the top is set to the relative pronoun required at the end of one of the RelHeadPaths. The dashed anaphoric connection is not established in the syntax.

(46) a. NP ⟶ NP ↑=↓ CP ↓∈(↑ adj)

b. CP ⟶ XP @(topic ↑ ↓) (↑ RelTopicPaths) = ↓ (↑ head) = (↓ RelHeadPaths & RelPro) IP ↑=↓

where RelTopicPaths is {comp, xcomp, ...}* \comp
RelHeadPaths is {spec*, [(obl$_\theta$) obj]*}
RelPro is gf* gf (→ prontype) $=_c$ rel

c. *which* Pro (↑ pred) = 'pro'
(↑ prontype) = rel

Sentence (47) exemplifies a pattern for English relative clauses that is not derived by rule (46b).

(47) The books (that) the shop sells __ are expensive.

The embedded clause in this sentence does not begin with an external XP topic phrase. Rather, the XP position of (46b) is either filled with the complementizer *that* or is left completely empty, and in either case there is no explicit relative pronoun to trigger an anaphoric interpretation. The alternative CP expansion in (48) accounts for these c-structure configurations, simulates the anaphoric link by introducing a null pronoun, and identifies directly the within-clause function for the value of the head attribute.

(48) CP ⟶ *that* | *e* @(topic ↑ (↑ head)) (↑ RelTopicPaths) = (↑ head) (↑ head pred) = 'pro' IP ↑=↓

This produces (49) as the f-structure for the relativized matrix subject NP in (47) (now omitting the projection arrows that presumably map the HEAD by default to the i-structure topic).

(49)
$$\left[\begin{array}{ll}
\text{PRED} & \text{`BOOK'} \\
\text{NUM} & \text{SG} \\
\text{DEF} & + \\
\text{CASE} & \text{NOM} \\
\text{ADJ} & \left\{\left[\begin{array}{ll}
\text{HEAD} & \left[\begin{array}{ll}\text{PRED} & \text{`PRO'}\end{array}\right] \\
\text{PRED} & \text{`SELL}\langle\text{SUBJ OBJ}\rangle\text{'} \\
\text{TENSE} & \text{PRESENT} \\
\text{SUBJ} & \left[\begin{array}{ll}
\text{PRED} & \text{`SHOP'} \\
\text{NUM} & \text{SG} \\
\text{DEF} & + \\
\text{CASE} & \text{NOM}
\end{array}\right] \\
\text{OBJ} &
\end{array}\right]\right\}
\end{array}\right]$$

The HEAD ‘PRO’ is an essential ingredient of this commonly accepted analysis of relative clauses. On this account the semantic connection between the head noun and its role within the clause is established without a direct syntactic relationship. This has the advantage that unwanted inconsistencies of any double-function syntactic feature values cannot arise (cf. the anaphoric solution for *tough*). However, Falk (2010) puts forth several arguments against what he describes as this “anaphorically mediated” analysis.

On one line of attack he points to the contrast in (50). While the word *headway* in the idiom *make headway* can be the head of a relative clause (50a), it cannot otherwise be an antecedent for a referential pronoun (50b).

(50) a. Mary praised the headway that John made.
b. * Mary always praises headway when John makes it.

As another argument, he notes (citing Maxwell 1979) that languages with pronounless relative clauses are quite common among the 49 languages listed in the NP accessibility database of Keenan & Comrie (1979). He illustrates this with examples from a number of languages, including the ones in (51) (*that* is a complementizer in the English translations, not a pronoun).

(51) a. Hebrew (from Falk 2010)
meabed hatamlilim še Bill maadif.
processor DEF.texts COMP Bill prefers
‘the word processor that Bill prefers’

b. Japanese (from Keenan & Comrie 1979)

Watashi	wa	sono	otoko	ga	tataita	inu	o	miru.
I	TOP	that	man	NOM	struck	dog	ACC	see

'I see the dog that the man struck.'

Some languages allow relative clauses with or without relative pronouns, like English, but relative pronouns simply do not exist in Japanese and other languages. Falk thus suggests that relative clauses without mediating pronouns are the typical case cross-linguistically, and that English examples like (43) are more the exception than the rule. A general account of head dependencies, he concludes, should not rely on the machinery of anaphoric binding.

Falk (2010) thus proposes an anaphorically-unmediated account of the connection between the f-structure of the relativized NP and the HEAD f-structure of the clause. The restriction operator is used to prevent selected features from clashing, along the lines of the *tough* analysis in (40) above. His proposal in essence is to augment the relative clause introduction rule (46a) with an equation that identifies the NP's (restricted) f-structure with the (restricted) HEAD of the clause (52).[7]

(52) $$\mathrm{NP} \longrightarrow \underset{\uparrow=\downarrow}{\mathrm{NP}} \quad \underset{\substack{\downarrow\in(\uparrow\ \textsc{adj})\\ \uparrow\backslash_{\{\textsc{case},\,\textsc{adj}\}}=(\downarrow\ \textsc{head})\backslash_{\{\textsc{case},\,\textsc{adj}\}}}}{\mathrm{CP}}$$

This permits the CASE feature of the NP and the relative HEAD to disagree; the relative-containing ADJ set is also restricted to avoid the technical confusion of circularity. The modified rule figures in the derivation of relative clauses with or without relative pronouns. English clauses with pronoun-containing initial XP phrases are still derived by rule (46b), but the relative pronoun no longer introduces its own pronominal PRED (53a). Instead the HEAD explicitly shares the head noun's PRED, thus establishing the semantic connection. Rule (48) is also simplified, since the null 'PRO' is not needed to compensate for the absence of an initial XP (53b).

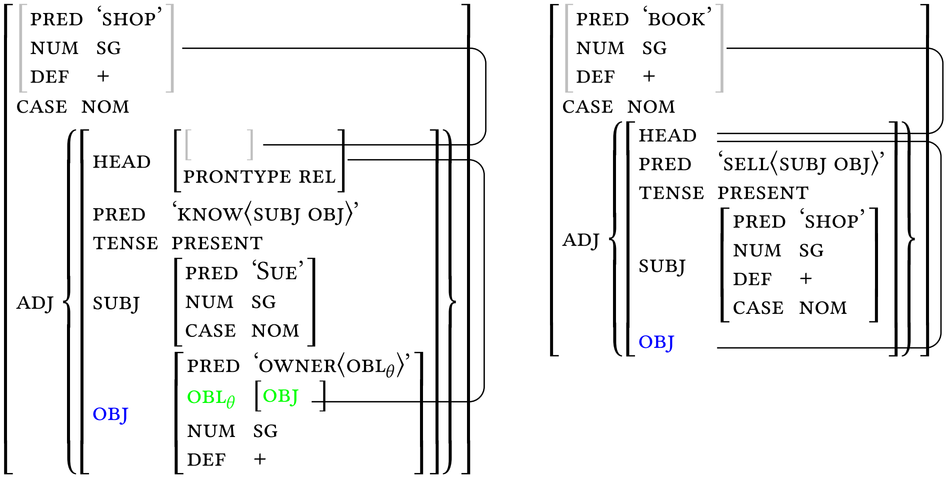
(53) a. *which* Pro (↑ PRONTYPE) = REL

b. $$\mathrm{CP} \longrightarrow \underset{\substack{@(\textsc{topic}\ \uparrow\ (\uparrow\ \textsc{head}))\\ (\uparrow\ \textsc{head})=(\uparrow\ \textsc{RelTopicPaths})}}{\textit{that}\,|\,e} \quad \underset{\uparrow=\downarrow}{\mathrm{IP}}$$

[7] The attribute HEAD is neutral with respect to Falk's semantically-oriented OPER attribute and the attribute RELPRO that aligns more with previous anaphora-based solutions.

With these revisions the f-structure (54a) is provided for the relativized NP *shop* in (43) and (54b) is provided for *book* in (47).

(54) a. b.



In these structures the link between the restricted HEAD f-structures is strictly local. The links within the clause are unbounded, as indicated by the colored attributes from paths in the RelTopicPaths and RelHeadPaths uncertainty languages.

7 Further constraints on uncertainty paths

In modern LFG theory the admissibility of particular unbounded dependencies is determined first and foremost by the attribute strings in the uncertainty path-languages. But these dependencies have been challenging for linguistic description because they are also conditioned in different constructions and different languages by second-order interactions with other structural properties. Dependencies and the phrases they pass through must sometimes be aligned with respect to special morphological or phonological feature values (Section 7.1). Separate dependencies in some languages cannot pass through the same f-structures, giving rise to so-called "island" effects (Section 7.2). Unbounded dependencies are of course related indirectly to word order by virtue of a grammar's normal c-structure rules and f-structure annotations, but they may also be sensitive to additional linear order constraints (Section 7.3).

7.1 Marking of intervening f-structures

Zaenen (1983) discussed a number of languages in which f-structures on a path between a filler and its clause-internal function differ in form from f-structures that are not in the domain of an unbounded dependency. She specifically considered Irish and Kikuyu, but since then many more cases have been discussed in the literature (see e.g. van Urk 2020). Here I focus on just the Irish examples of the phenomenon, as illustrated by the contrasts in (55) (data originally from McCloskey 1979).[8]

(55) Path-dependent complementizer selection in Irish

a.

Deir	siad	goN/*aL	síleann	an	t-athair	goN/*aL	bpósfaidh	Síle	é.
Say	they	that	thinks	the	father	that	will-marry	Sheila	him

‘They say that the father thinks Sheila will marry him.’

b.

An	fear	aL/*goN	deir	siad	a	shíleann	an	t-athair	aL/*goN
The	man	that	say	they	that	thinks	the	father	that

phósfaidh	Síle.
will-marry	Sheila

‘The man that they say that the father thinks Sheila will marry __.’

Embedded complements not on a binding path (55a) are introduced by the complementizer *goN* and not *aL*, while *aL* is required for complements that the relative-clause dependency passes through (55b). This pattern has a simple account if all and only intervening f-structures on a dependency path are marked with a distinguishing diacritic feature [UBD GAP] (for “gapped unbounded dependency”). That feature would then be available for checking by the complementizers’ lexical annotations (56).[9]

(56) Irish complementizers

aL	C	(↑ UBD)
goN	C	¬(↑ UBD)

The positive existential constraint would not be satisfied if *aL* appears with a COMP that does not have a UBD feature, and the negative existential for *goN* would fail if that feature is present.

[8] In the linguistic literature the complementizer *a* is typically written as *aL* or *aN*, indicating that it triggers a lenition mutation or a nasalization mutation on the following word.

[9] This is a respelling of the LDD (“long distance dependency”) feature that appears in Dalrymple et al. (2019) and elsewhere. Ash Asudeh (p.c.) argues that UBD is a more accurate designation, since some instances of these constructions are actually quite short. Falk (2009) proposes a feature WHPATH for related path-marking purposes.

Working within the original Kaplan & Bresnan (1982) c-structure formulation of unbounded dependencies (Section 2.1), Zaenen (1983) added the f-structure marking feature (BND in her account) at sentential bounding nodes in a successive-cyclic fashion. In the modern functional framework, a basic uncertainty leaves no footprints as it passes through the intervening f-structures along a path, but its presence can be made known by adding off-path annotations to the attributes of the regular expression. Off-path constraints were formalized originally by Kaplan & Maxwell (1996) and Crouch et al. (2011); see also Dalrymple et al. (2019).

An off-path annotation is a functional description attached to an attribute in an ordinary functional designator, much like traditional descriptions are attached to c-structure categories. The difference is that an off-path annotation can use metavariables ← and → instead of (or in addition to) ↑ and ↓. These are instantiated to the f-structure containing the annotated attribute and the value of that attribute in the containing f-structure, respectively. A formal definition is given in (57).

(57) Off-path annotations

$(f\ \underset{D}{a}) = v$ iff $(f\ a) = v$ and $D_{\substack{\leftarrow/f\\ \rightarrow/v}}$ is satisfied, where

D is a functional description and

$D_{\substack{\leftarrow/f\\ \rightarrow/v}}$ is the result of substituting f for ← and v for → in D.

This definition extends the notation and meaning of primitive function-application designators (12a) and thus immediately carries over to the path languages of functional uncertainties (cf. (13a)).

Off-path annotations were first used in a functional account of Irish complementizer marking that was developed in unpublished research by Mary Dalrymple, Ronald Kaplan, John Maxwell, and Annie Zaenen; Dalrymple (2001) provided the first published account of this approach. In essence, the uncertainty expression defined in (58a) inserts the UBD feature at every intervening f-structure without imposing any further restrictions on the grammatical functions along the path. The RELTOPICPATHS schema (58b) then applies regular-language intersection to mark the attributes of whatever path language is separately specified.

(58) a. MARK = $\underset{(\leftarrow\ \text{UBD})=\text{GAP}}{\text{GF}^*}$ GF

b. RELTOPICPATHS = […] & MARK

The off-path annotation adds the UBD features parallel to the COMPS in (59), the f-structure for (the English gloss of) sentence (55b), and the lexical constraints (56) then assure the proper distribution of complementizers.

(59)
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\left[\begin{array}{ll} \textsc{pred} & \text{‘man’} \\ \textsc{num} & \textsc{sg} \\ \textsc{def} & + \end{array}\right]} \\ \textsc{adj} & \left\{\left[\begin{array}{ll} \textsc{head} & \\ \textsc{pred} & \text{‘say}\langle\textsc{subj comp}\rangle\text{’} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{‘pro’} \\ \textsc{num} & \textsc{pl} \end{array}\right] \\ \textsc{comp} & \left[\begin{array}{ll} \textsc{pred} & \text{‘think}\langle\textsc{subj comp}\rangle\text{’} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{‘father’} \\ \textsc{num} & \textsc{sg} \\ \textsc{def} & + \end{array}\right] \\ \textsc{comp} & \left[\begin{array}{ll} \textsc{pred} & \text{‘marry}\langle\textsc{subj obj}\rangle\text{’} \\ \textsc{subj} & \left[\begin{array}{ll} \textsc{pred} & \text{‘Sheila’} \end{array}\right] \\ \textsc{obj} & \end{array}\right] \\ \textsc{ubd} & \textsc{gap} \end{array}\right] \\ \textsc{ubd} & \textsc{gap} \end{array}\right]\right\} \end{array}\right]$$

Asudeh (2012) discusses the more complicated relative clause patterns of Irish described by McCloskey (2002). Generally, the head nominal is assigned a within-clause function that has no surface realization (a gap), as in (59), if every intervening clause is marked with *aL*. But if the nasalization mutation triggered by *aN* appears at any clause along the way, then additional UBD marking is suspended and the head must bind to an explicit resumptive pronoun found in that clause or below. McCloskey (2002) illustrates this pattern with the relative clause in (60).

(60) Irish

aon	duine	a	cheap	sé	a	raibh	ruainne tobak	aige
any	person	aL	thought	he	aN	was	scrap tobacco	at-him

‘anyone that he thought had a scrap of tobacco’

This motivates the more elaborate version of the marking language shown in (61a). Here the f-structures on an arbitrary (possibly empty) prefix of an uncertainty path are marked with the feature [UBD GAP], as before. But at any point along the path the marking value for embedded f-structures can optionally switch to RES(umptive). Intersecting the language RESOLVE in (61b) forces the uncertainty to resolve to a resumptive pronoun only when the RES value has been chosen.

(61) Irish gap marking (with resumptives)

a. $\textsc{Mark} = \underset{(\leftarrow\ \textsc{ubd}) = \textsc{gap}}{\textsc{gf}^*} \left(\underset{(\leftarrow\ \textsc{ubd}) = \textsc{res}}{\textsc{gf}^*} \right)$

b. $\textsc{Resolve} = \text{GF}^{*} \underset{(\leftarrow\ \text{UBD}) = \text{RES iff } (\rightarrow\ \text{PRONTYPE}) =_c \text{RES}}{\text{GF}}$

c. $\textsc{RelTopicPaths} = [\ \ldots\ ]\ \&\ \textsc{Mark}\ \&\ \textsc{Resolve}$

The lexical annotations (62) then make sure that the complementizers along the way are properly correlated with how the uncertainty is resolved at the bottom.

(62) *aL* C $(\uparrow \text{UBD}) =_c \text{GAP}$
aN C $(\uparrow \text{UBD}) =_c \text{RES}$

For the relative clause (60) this analysis gives rise to the abbreviated f-structure (63).

(63)
$$\left[\begin{array}{ll} \multicolumn{2}{l}{\left[\text{PRED}\ \ \text{`PERSON'}\right]} \\ \text{ADJ} & \left\{\left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{l} [\ \ ] \\ \text{PRONTYPE RES} \end{array}\right] \\ \text{PRED} & \text{`THINK}\langle\text{SUBJ COMP}\rangle\text{'} \\ \text{SUBJ} & \left[\text{PRED}\ \ \text{`PRO'}\right] \\ \text{COMP} & \left[\begin{array}{ll} \text{PRED} & \text{`HAVE}\langle\text{SUBJ OBJ}\rangle\text{'} \\ \text{SUBJ} & \\ \text{OBJ} & \left[\text{PRED}\ \ \text{`SCRAP'}\right] \\ \text{UBD} & \text{RES} \end{array}\right] \\ \text{UBD} & \text{GAP} \end{array}\right]\right\} \end{array}\right]$$

Asudeh (2012) provides an altenative treatment of this and other patterns of Irish relatives. On his account the entire head f-structure, not just an atomic feature, is instantiated at every clause along the path. In this successive cyclic COMP-to-COMP arrangement, the head appears in the *aN*-complementizer clause in particular, and the pronoun binding is then set up there by a new uncertainty launched by *aN*'s lexical annotations. The marking strategy (61a), by comparison, offers the transition from gap to pronoun as a feature-controlled choice at any point within a single uncertainty language. It allows both the gap and the pronoun to be bound in the same end-to-end fashion, without any intermediate landing sites. This produces a less cluttered f-structure while making the claim that features of the particular head do not interact with properties of any intermediate clauses.

For Irish it is the selection of complementizers that interacts with unbounded dependency paths. The Kikuyu data cited by Zaenen (1983) and Dalrymple (2001) show that the verbs in intervening f-structures may also be sensitive to the presence of a dependency. This effect may be seen also in English: unbounded dependencies freely propagate through the complements of some verbs (64a) while (at least for some speakers) the complements of other verbs act as barriers (64b).

(64) a. Mary, we thought that Henry called.
b. * Mary, we whispered that Henry called.

Verbs like *think* are called bridge verbs, while *whisper* belongs to the class of nonbridge verbs. If the simpler Mark in (58a) is applied to the sets of English uncertainty paths, then the difference in behavior is accounted for by the negative existential in (65b).[10]

(65) a. *think* V (↑ PRED) = 'THINK⟨SUBJ COMP⟩'
b. *whisper* V (↑ PRED) = 'WHISPER⟨SUBJ COMP⟩'
¬(↑ UBD)

This captures the syntactic difference between bridge and nonbridge verbs, but that difference may be a structural reflection of a more basic semantic or pragmatic difference. Erteschik-Shir (1973) suggested that verbs that imply the manner of saying something are more likely to form islands than verbs that simply describe what is being said. It is not clear whether the various constraints on unbounded dependencies that can be formalized with LFG's syntactic machinery are better explained by appeal to other components of grammar, or to principles of cognition, pragmatics, or computation.

In these illustrations the unbounded dependency announces itself by the value it defines for the special UBD feature, and that value can then be examined to limit the f-structures that the dependency passes through. English adjuncts appear to interact with unbounded dependencies in a different way. Sentence (66a) was cited earlier to show that adjuncts can be topicalized and that the topicalization path-language (for English, not Icelandic) should include ADJ (∈) as an option. But the ungrammaticality of example (66c) indicates that an additional restriction must be imposed on the general pattern (examples from Dalrymple 2001).

(66) a. This room Julius teaches his class in __.
b. We think that David laughed after we selected Chris.
c. * Chris, we think that David laughed after we selected __.

[10] Dalrymple et al. (2019) formalize the bridging restriction by pairing a negative defining equation (↑ LDD) = − on *whisper* with an off-path negative value constraint (↑ LDD) ≠ − in the uncertainty. The LDD feature thus always appears in the complement f-structures of nonbridge verbs, even if not in the context of an unbounded dependency. In the solution outlined here that feature appears always and only along a dependency path and is available there for the bridge verb to test.

This difference has been ascribed to the fact that the ADJ clause is tensed in (66c) but not (66a), although there may be other pragmatic or semantic factors also at work (see Toivonen 2021 and references cited there).

Taking the bridge verbs as a model, tensed adjuncts could be excluded from unbounded dependencies by adding a negative existential constraint $\neg(\uparrow \text{UBD})$ to every tensed verb. But it is more economical to leave all the verbs alone and instead to refine just the uncertainty so that it cannot pass to or through a tense-marked ADJ element. The path language (67a) and the intersection (67b) impose that constraint on TopicPaths (Dalrymple 2001 and Dalrymple et al. 2019 formulate TAC in a slightly different but equivalent way).

(67) Tensed Adjunct Constraint[11]

a. $\text{TAC} = \backslash[\underset{(\rightarrow\ \in\ \text{TENSE})}{\text{ADJ}}]^*$

b. $\text{TopicPaths} = [\{\text{COMP}, \text{XCOMP}, \text{ADJ}\ (\in)\}^*\ \backslash\text{COMP}]\ \&\ \text{MARK}\ \&\ \text{TAC}$

The TAC restriction can be applied with a similar intersection to FocusPaths and the path languages of other constructions, as appropriate.

However, examples (68) indicate that grammaticality is not correlated with the presence of absence of the TENSE feature. The participial adjunct in (68a) is untensed and therefore the inadmissible dependency in (68b) would not be ruled out by the Tensed Adjunct Constraint.

(68) a. The cat slept after devouring the rat.

b. * What did the cat sleep after devouring __?

Instead, what is common to the ungrammatical examples in (66) and (68) is the presence of a subject, either derived from an explicit phrase (66c) or inserted as an anaphorically controlled null pronoun (68b). Unbounded dependencies may thus be more sensitive to the constraint as formulated in (69).

(69) Subject Adjunct Constraint

$\text{SAC} = \backslash[\underset{(\rightarrow\ \in\ \text{SUBJ})}{\text{ADJ}}]^*$

Like many other conditions, restrictions on adjunct dependencies seem to be language-particular and not universal. Swedish for example seems to be more

[11]Intersection and term-complementation of off-path annotations can be reduced to more primitive expressions by noting the equivalences of $\underset{D_1}{a}\ \&\ \underset{D_2}{a}$ and $\underset{D_1 \wedge D_2}{a}$ and of $\backslash[\underset{D}{a}]$ and $\{\backslash \underset{D}{a}, \underset{\neg D}{a}\}$.

flexible than English in this regard (see Müller 2019). It is an advantage of the LFG approach that such constraints can be expressed easily within the formalism without appeal to extragrammatical (and often false) general principles.

7.2 Classical island constraints

Early interest in unbounded dependencies was mainly stimulated by the constraints on them that were first described in detail by Ross (1967). Working within a framework of transformational rules, Ross gave a list of "island" configurations that block the movement of constituents from one clause to another. He observed in particular that sentential subjects, coordinate structures, and complex NPs all seem to interfere with unbounded relationships, as the contrasts in (70) suggest (after Ross 1967).

(70) Sentential Subject Constraint

a. The reporters expected that the principal would fire some teacher.

b. The teacher who the reporters expected that the principal would fire __ ...

c. That the principal would fire some teacher was expected by the reporters.

d. * The teacher who that the principal would fire __ was expected by the reporters ...

Coordinate Structure Constraint

e. Henry plays the lute and sings madrigals.

f. * The lute which Henry plays __ and sings madrigals ...

g. * The madrigals which Henry plays the lute and sings __ ...

Complex NP Constraint

h. Phineas knows a girl who __ is jealous of Maxime.

i. * Who does Phineas know a girl who __ is jealous of __?

j. * Maxime, Phineas knows a girl who __ is jealous of __.

It appeared that transformations cannot move the constituents of sentential subjects (70a–70d), that parts of individual conjuncts in a coordination cannot be moved (70e–70g), and that the complex NPs of relative clauses also form a barrier (70h–70j). Ross formulated these island constraints in phrase-structure terms and appealed to extra-grammatical (and presumably universal) stipulations to impose them on the otherwise unfettered operation of individual transformational rules.

Later transformational accounts maintained the view that unbounded dependencies are allowed except when they would cross into phrasal islands, and this conception was carried over into the early c-structure-based LFG approach. Kaplan & Bresnan (1982) and Zaenen (1983) provided a grammar-internal way of limiting the range of the bounded-domination metavariables ⇑ and ⇓ and thus enabled more fine-grained characterizations of island configurations. They permitted particular categories in c-structure rules to be marked as "bounding categories", and nodes licensed by those categories were not allowed on the dominance paths connecting co-instantiations of ⇑ and ⇓. For example, the ungrammaticality of (70i) would follow on that theory if the CP under NP in rule (46a) is marked as a bounding category. But there is no need for such categorial distinctions in the modern LFG theory of unbounded dependencies, since the vocabulary of grammatical functions and features provides a natural platform for expressing such island-like restrictions.

Ross' Sentential Subject Constraint, for instance, can be expressed by the term-complement formula (71a). This defines paths of arbitrary length that do not pass through subjects and that bottom out in any grammatical function. And the constraint could then be enforced by intersecting this with any other long distance regular language, as in (71b). Any paths with SUBJ-containing prefixes would no longer be available.

(71) a. SSC = \SUBJ* GF
b. RELTOPICPATHS = […] & SSC (English)
c. RELTOPICPATHS = SUBJ+ (Tagalog)

This restriction would be helpful for English relatives if there is an explanatory advantage in stating the basic path language in a simple but overly general way (e.g. [GF* \COMP]). But it would not be needed if the regular expression for the basic uncertainty defines the admissible paths more precisely. Either way, this is clearly not a universal constraint: Kroeger (1993) observes that the path language for Tagalog unbounded dependencies contains *only* subjects, as in (71c). Such an extragrammatical condition may have been the only way of regulating the operation of transformational rules, but it serves no particular purpose in the setting of functional uncertainty.

Coordinate structures in LFG are represented formally as conjunct-containing sets under distributive attributes, and their behavior with respect to f-structure well-formedness is specified in (12e), repeated here for convenience. A set satisfies a distributive f-structure property if all of its elements satisfy that property. While this account of coordination is defined only for local f-structure configurations, unbounded dependencies simply inherit that local behavior by virtue of the incremental, single-attribute expansion of functional uncertainty as spelled out in (13a), also repeated.

(12e) $(f\ a) = v$ iff f is a set and
$(g\ a) = v$ for all $g \in f$ if a is a distributive attribute
$\langle a, v\rangle \in f$ if a is a nondistributive attribute.

(13a) If PATHS is a set of attribute strings,
$(f\ \textsc{Paths}) = v$ iff $((f\ a)\ \mathit{Suff}(a, \textsc{Paths})) = v$.

The pattern of coordinate structure violations illustrated in (70e-g), and in (10) above, follows immediately from this independent theory of coordination: without further stipulation, a dependency that crosses into a coordination cannot affect just one of the conjuncts.[12]

An NP is "complex" for Ross if it immediately dominates a clausal category (CP now, S as originally formulated). The essence of the Complex NP Constraint is that no unbounded dependency can relate an element outside such an NP to an element inside the dominated clause. Examples (70i) and (70j) are ungrammatical on this theory because the relativized NPs are complex in this way and thus are opaque to the question and topicalization dependencies. Our framework offers a different account of their ill-formedness: the clauses are represented in f-structure as adjuncts of the head noun *girl* and so do not satisfy Subject Adjunct Constraint installed in the English FOCUSPATHS and TOPICPATHS path sets. As noted above, TAC is not universal, it applies in English but not for instance to Swedish dependencies. It is not surprising that the Complex NP Constraint also does not seem to operate in Swedish (Müller 2019).

[12]The suffix language for a chosen attribute must propagate into each conjunct, but Kaplan & Zaenen (1989) note that the residual uncertainties are then not required to resolve all in the same way:

(i) Mary, John expected to see __ and give the book to __.

Here the set of XCOMP suffix paths resolves to OBJ in the first complement but $\textsc{obl}_\theta$ in the second. In contrast, Saiki (1985) observes that some Japanese relative clauses are constrained so that the dependencies in all conjuncts must resolve either to a subject or to a non-subject. This constraint can be imposed by intersecting $[\textsc{gf}^*\ \textsc{subj} \mid \textsc{gf}^*\ \backslash\textsc{subj}]$ with the basic Japanese path specification.

The CNPC characterizes English relative clauses (with assignments to ADJ) as islands for unbounded dependencies. It does not cover other cases where dependencies seem to be mutually exclusive. Example (72b) shows that two question dependencies cannot overlap, (72c) shows that a topicalization cannot pass into a question, and (72d) shows that a question also obstructs a relative clause dependency. None of these involve complex NPs.

(72) a. Phineas wonders which girl is jealous of Maxime.
  b. * Who does Phineas wonder which girl __ is jealous of __?
  c. * Maxime, Phineas wondered which girl __ is jealous of __.
  d. * The girl that Phineas wondered who __ is jealous of __ left.

On one approach the path languages for each of the outer dependencies can be conditioned against tell-tale properties of the innner question f-structure, presuming that those are recognizable and independently motivated (for example, if a grammaticized FOCUS attribute is still needed for some other reason). Falk (2009) proposes instead to make use of the path-marking feature UBD (his WH-PATH) that is already needed for verb and complementizer selection. It is the inner construction that then determines whether to protect itself from other unbounded dependencies. English embedded questions thus become dependency islands when a negative UBD constraint is added to the rule (73) that introduces them.

(73) $$\mathrm{CP} \longrightarrow \begin{array}{cc} \mathrm{XP} & \mathrm{IP} \\ @(\textsc{FocusQ}\ \uparrow\ \downarrow\ (\downarrow\ \textsc{WhPaths}\ \&\ \textsc{WhPro})) & \uparrow{=}\downarrow \\ (\uparrow\ \textsc{FocusPaths}) = \downarrow & \\ \neg(\uparrow\ \textsc{ubd}) & \end{array}$$

It may not be an accident that the constraint that blocks an outer unbounded dependency co-occurs with an equation that launches an inner one, as in this rule. Some but not all languages may use this as a strategy to keep at bay the confusion of too many overlapping uncertainties.

7.3 Constraints on linear order

In the unbounded dependency constructions examined so far, an uncertainty is launched from an overt c-structure constituent or lexical item and binds the content of that element to a remote position in f-structure. The uncertainty is outside-in for most of the constructions, where the external element is realized perhaps far away from the normal c-structure location of its within-clause function assignment. The uncertainty is inside-out when the overt element of a dependency is in situ, as in the Mandarin example (21). These purely functional accounts go through without making reference to c-structure positions that correspond to the other, covert ends (bottom or top) of the dependencies. So far there has been no need for the phonologically empty nodes or traces that have been an essential ingredient of other theories of syntactic binding.

However, there are well known cases to suggest that the bottom end of an outside-in uncertainty must be grounded at a specific c-structure position, that the external element must be associated with a within-clause c-structure position in addition to a within-clause function. The weak crossover pattern in (74), first discussed by Wasow (1979), has received the most attention. Controlling for other possibly relevant factors, this shows an interaction between the linear position of the pronoun and the within-clause position where the OBJ or OBL_θ function assigned to *who* would normally be expressed. The pronoun *his* and *who* cannot refer to the same individual if the pronoun comes before the assumed within-clause position of *who*:

(74) Weak crossover (examples from Dalrymple et al. 2001)

a. * Who$_i$ did his$_i$ mother greet __?
(cannot mean: Whose$_i$ mother greeted him$_i$?)

b. * Who$_i$ did Sue talk to his$_i$ mother about __?

c. Who$_i$ did Sue talk to __ about his$_i$ mother ?

The English contrast in (75) has also been taken as evidence that within-clause locations must be assigned to the external elements of question and *tough* constructions (see Kaplan & Bresnan (1982) and references cited therein). Sentence (75b) is uninterpretable because the link from *sonata* to its putative within-clause position crosses over the link from the overt appearance of *violin* to its covert linear position.

(75) Nested syntactic dependencies

a. Which violin is this sonata easy to play __ on __.

b. * Which sonata is that violin easy to play __ on __.

The ordering patterns illustrated by these examples are not found in all languages. Maling & Zaenen (1982), for example, note that crossing dependencies are acceptable in Norwegian and only dispreferred in Swedish. It must therefore be possible to parameterize or otherwise express these restrictions in the grammars of individual languages.

7.3.1 Ordering by (empty) trace nodes

Bresnan (2001) proposed to handle the linear ordering facts of weak crossover within a larger cross-linguistic theory of anaphoric binding.[13] She expands the NP at the within-clause position to an empty string, and then arranges for the ϕ correspondence function to map both the trace node and the NP at *who* to the same f-structure (e.g. OBJ or OBL$_\theta$). That many-to-one correspondence is set up by converting the uncertainty from outside-in to inside-out and shifting its launch site to the new trace node, as illustrated in (76).[14]

(76) a. CP $\longrightarrow$ XP: @(FocusQ $\uparrow$ $\downarrow$ ($\downarrow$ WhPaths & WhPro)) ~~($\uparrow$ FocusPaths) = $\downarrow$~~ $\neg$($\uparrow$ UBD); IP: $\uparrow$=$\downarrow$

b. NP $\longrightarrow$ *e*: $\uparrow$= (FocusPaths $\uparrow$)

With node mappings set up in this way, the weak crossover constraint on linear order can be stated in terms of the f(unctional)-precedence relation defined in (77): a pronoun cannot f-precede its antecedent.[15]

[13]For the general theory of anaphoric binding this proposal is part of, see Rákosi forthcoming [this volume]. On the Bresnan (2001) theory a pronominal cannot be more "prominent" than its potential antecedents, where prominence for a given language may be based on relative positions on a hierarchy of grammatical functions (SUBJ is more prominent than OBJ), on a hierarchy of thematic roles (AGENT is more prominent than PATIENT), or on the linear order of corresponding c-structure nodes. Only the linear prominence condition is relevant for these particular examples of weak crossover in English.

[14]This analysis was also carried over into Bresnan et al. (2016), but the later co-authors are not in full agreement about the status of empty elements and whether dependencies should run outside-in or inside-out (Ash Asudeh, p.c.).

[15]Bresnan's f-precedence definition (77) differs from the proposals of other authors. It compares the positions of only the right-most nodes of the inverse-ϕ images, while Kaplan & Zaenen (1989) and others take into account all nodes in the correspondence.

(i) Functional precedence (Kaplan & Zaenen 1989)
$f <_f g$ iff for all $n_1 \in \varphi^{-1}(f)$ and all $n_2 \in \varphi^{-1}(g)$, n_1 c-precedes n_2 ($n_1 <_c n_2$).

These definitions are equivalent for purposes of this discussion.

(77) Functional precedence Bresnan (2001)
f f-precedes g ($f <_f g$) iff the rightmost node in $\varphi^{-1}(f)$ c-precedes the rightmost node in $\varphi^{-1}(g)$.

However, separating the uncertainty specification from the dependency's overt element comes at a descriptive cost. Without some further stipulation the grammar would accept a phrase in the XP position of (76a) even when it corresponds to no FocusPath trace node in the clause c-structure and thus is assigned no within-clause function. This issue has been addressed by introducing a global condition on well formed f-structures, the Extended Coherence Condition. This was first proposed by Zaenen (1985); this version is taken from Dalrymple (2001):[16]

(78) Extended Coherence Condition
focus and topic must be linked to the semantic predicate argument structure of the sentence in which they occur, either by functionally or anaphorically binding an argument.

This important requirement can be reconstrued as a well-formedness condition on grammars rather than on representations. Functional binding is guaranteed if the simple existential constraint (79) is attached as an additional annotation to the filler XP in (76a).

(79) Extended coherence constraint
((gf ↓) pred)

Depending on how the relationships of anaphoric binding are made formally explicit, a similar constraint can be defined for those linkages.

Another convention is needed to prevent the proliferation of trace nodes at different c-structure positions whose inside-out uncertainties would bind a single filler to the same or different within-clause functions (but see Section 8). One motivation for Bresnan's Economy of Expression principle (80) is to exclude derivations that contain such unwarranted trace bindings.[17]

(80) Economy of Expression (Bresnan et al. 2016)
All syntactic phrase structure nodes are optional and are not used unless required by independent principles (completeness, coherence, semantic expressivity).

[16]If grammaticized discourse functions are not represented in f-structure, the intuition behind this constraint would have to be reformulated as a condition on i-structure correspondences.

[17]Separately, Dalrymple et al. (2015) present a critical discussion of Economy as a general principle of syntax.

Extended Coherence and Economy help to control the promiscuous behavior of trace-launched uncertainties, those that are not directly associated with overt triggering configurations.[18]

As a final observation, it is also not clear whether or how well the Bresnan account of weak crossover ordering extends to characterize the nested dependency pattern in examples (75), given that the path languages for the question and *tough* constructions are not the same. Careful regulation of empty-node ordering offered a solution to the *sonata/violin* contrast in the original LFG theory of unbounded dependencies (Kaplan & Bresnan 1982), but the c-structure stipulations of that theory do not naturally carry over to the path languages of modern approaches.

7.3.2 Ordering by coarguments

Dalrymple et al. (2001) use a different definition of linear prominence based on the notion of coargumenthood and a relation between the pronoun and the f-structure that contains the wh-term (called the "operator"). With this formulation they show that the linear order constraints of weak crossover can be modeled without appealing to traces. They define coarguments as the arguments and adjuncts of a single predicate[19] and propose that both of the following prominence conditions must be satisfied:

(81) Let CoargOp and CoargPro be coargument f-structures such that CoargOp contains the within-clause function of the operator (wh-term) and CoargPro contains the pronoun. Then:

Syntactic [= Functional] Prominence: An operator O is more prominent than a pronoun P if and only if CoargOp is at least as high as CoargPro on the functional hierarchy.

[18] Although it has not been explored in the literature and I am not advocating for it here, there is a trace-based alternative that may be somewhat less unattractive. On this analysis the trace is used only to establish a within-clause linear position for the uncertainty: it does not serve as a launching site. The uncertainty remains with the overt external element, but each path language (e.g. FocusPaths) is intersected with the off-path annotations in Locate (i) to guarantee that it ends at a function assigned at a c-structure trace node. The bookkeeping feature trace is defined at all and only trace nodes.

(i) $\textsc{Locate} = \textsc{gf}^{*} \begin{array}{c}\textsc{gf}\\ (\rightarrow\ \textsc{trace})\\ (\rightarrow\ \textsc{ubd}) = \textsc{gap}\end{array}$ $\qquad \text{NP} \longrightarrow \begin{array}{c}e\\ (\uparrow\ \textsc{trace}) = +\\ (\uparrow\ \textsc{ubd})\end{array}$

[19] Dalrymple et al. (2019) note that "co-dependent" may be a more accurate label for this concept, since adjuncts are included along with arguments. Here I continue to use the terminology of the original paper.

> Linear Prominence: An operator O is more prominent than a pronoun P if and only if CoargOp f-precedes CoargPro.

The key idea is that Linear Prominence depends on the f-precedence relations of the coarguments, the clause-internal f-structure sisters that contain the operator and pronoun. The positions of the nodes that the outside-in uncertainty maps to the coarguments in the weak crossover example (74a) are indicated in (82a). Note that CoargOp is located only at the leading position because its function OBJ is not projected from any clause-internal (trace) node. This sentence meets the Linear Prominence requirement, but fails the Syntactic Prominence test because OBJ is lower than SUBJ on the function hierarchy.

(82) a. * Who$_i$ did [his$_i$ mother] greet?
CoargOp CoargPro

b. * Who$_i$ did Sue talk [to his$_i$ mother] about?
CoargPro CoargOp

c. Who$_i$ did Sue talk to [about his$_i$ mother]?
CoargOp CoargPro

For examples (74b) and (74c) the oblique functions are at the same position on the functional hierarchy so they both meet the Syntactic Prominence condition. This grammaticality difference follows from the locations of the within-clause coargument nodes as annotated in (82b) and (82c) respectively. CoargPro is the OBL$_{\text{TO}}$ of *talk* in (82b) (because *his* is contained in the *to*-phrase) and CoargOp is the OBL$_{\text{ABOUT}}$ (because the outside-in uncertainty resolves to that function). The sentence is ungrammatical because the nodes mapping to CoargPro and CoargOp are in the wrong order. The Coargs and their order are switched in the grammatical sentence (82c).

On this proposal, the operator's within-clause function is first determined by an outside-in uncertainty. After that the coarguments are identified in the clause at which the paths to the operator and pronoun functions first diverge. Linear order is then defined on the nodes that map to those overt, lexicalized coargument functions. Weak crossover is the target of this particular account, but coargument precedence may apply more generally. The nested dependency constraint (75) may follow from a different coargument ordering requirement once the coargument functions are identified for the *violin* and *sonata* phrases.

(83) a. [Which violin] is [this sonata] easy to play on?
1 2/Coarg2 Coarg1

b. * [Which sonata] is [that violin] easy to play on?
1/Coarg1 2 Coarg2

The formal details of such an ordering principle have not yet been worked out.

7.3.3 Ordering by subcategorizing PREDicates

The subcategorizing predicate for a given grammatical function is the semantic form that licenses that function in a local f-structure, via the Coherence and Completeness conditions. The value of those conditions in linguistic description is obvious, but Kaplan & Maxwell (1988a) noted that they are also key to the computationally efficient resolution of functional uncertainties. A typical uncertainty allows for the full array of grammatical functions each of which must be hypothesized in principle at every level of embedding. The overall computational complexity is much reduced if that exploration is deferred until the subcategorizing predicate is reached: the possible realizations can then be limited to all and only the functions that it governs. Kaplan (1989a) made a related psycholinguistic processing observation: the results of early trace-inspired measures of word-by-word cognitive load experiments (Kaplan 1974, Wanner & Maratsos 1978) could also be attributed to additional activity when the subcategorizing predicate is first encountered. It was not recognized in these early studies that subcategorizing predicates could also be the basis for a trace-free account of linear order grammaticality conditions.

Pickering & Barry (1991) made a much more systematic sentence-processing argument that overt subcategorizing predicates and not empty categories determine how external elements are integrated into embedded clauses. Adopting their Direct Association Hypothesis, Dalrymple & King (2013) sketch an account of nested dependencies that depends on the linear order of the predicates that subcategorize for the bottom functions of overlapping uncertainty paths. They use the term "anchor" for the subcategorizing predicate of the bottom function, as illustrated in (84).[20]

(84) Anchor ordering

a. [Which violin] is [this sonata] easy to play on?
1 2 Anchor2 Anchor1

[20]This notion of "anchor" should not be confused with the formal definition used in the decidability proofs for LFG parsing and generation Kaplan & Wedekind forthcoming [this volume].

b. * [Which sonata] is [this violin] easy to play on?
1 2 Anchor1 Anchor2

In (84a) *violin* is anchored at the *on* predicate, as indicated by the arrow, because the outer uncertainty resolves to *on*'s OBJ. Similarly, the anchor for *sonata* is *play*. The anchoring predicates are the same in (84b), but they occur in the opposite linear order. Dalrymple and King make precise what it means for two dependencies to interact (intuitively, that the outer dependency unfolds through a clause containing the inner one). The difference between (84a) and (84b) then follows from their nesting condition: if two dependencies 1 and 2 interact, then Anchor1 must not precede Anchor2. Nadathur (2013) accounts for the linear order of weak crossover by a separate anchor-ordering constraint: the anchor of the operator must precede the pronoun.

Although Dalrymple & King (2013) and Nadathur (2013) do not give a detailed specification of their outside-in, anchor-based approaches to linear order, the basic notions are easy to represent within the existing LFG formalism. First, the anchor of an uncertainty path is the PRED of the f-structure one up from the bottom. The off-path annotation on the path language (85) picks out that PRED and adds it as a diacritic feature to the f-structure at the top of the path, where the uncertainty is launched.

(85) $\text{ANCHOR} = \text{GF}^* \underset{(\uparrow \text{ANC}) = (\leftarrow\ \text{PRED})}{\text{GF}}$

The effect of intersecting ANCHOR with any other path language (e.g. FocusPaths or ToughPaths) is to make the within-clause anchor directly available at the top, presumably at the operator's f-structure.

Second, PRED semantic forms in LFG are composite entities that encapsulate succinctly a collection of syntactic and semantic properties. These are accessible by distinguished attributes REL, ARG1, ARG2, etc. Semantic forms are also instantiated, and Kaplan & Wedekind forthcoming [this volume] make explicit that the instantiating index of a PRED is the value of another distinguished attribute SOURCE. Moreover, the value of SOURCE is the daughter node, formally denoted by $*$, at which the PRED is introduced into the f-description. Thus a defining equation (86) is implicitly carried along with every PRED.

(86) PRED instantiation (from Kaplan & Wedekind forthcoming [this volume])
$(\uparrow \text{PRED SOURCE}) = *$

A PRED-precedence relation (87) follows naturally from the immediate connection between instantiated semantic forms and c-structure nodes: semantic forms are ordered by the c-structure order of their instantiation SOURCE nodes.

(87) PRED precedence
$p_1 <_p p_2$ iff $(p_1 \text{ SOURCE}) <_c (p_2 \text{ SOURCE})$.

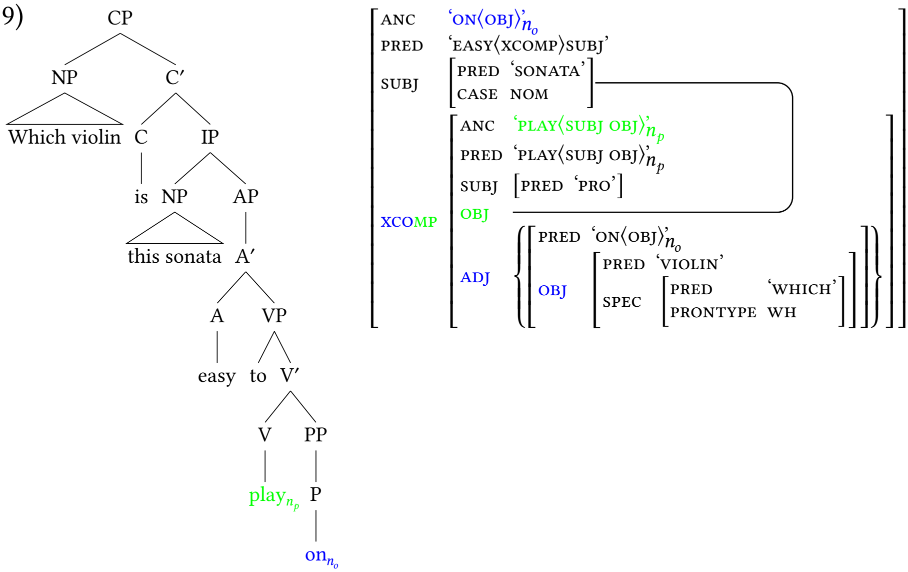
This is a simpler relation than f-precedence since it is defined directly on singleton nodes, not on ϕ^{-1} sets of nodes. Finally, the path language (88) encodes the nested-order constraint.

(88) $\text{NESTED} = \underset{(\uparrow \text{ ANC}) \not<_p (\rightarrow \text{ ANC})}{\text{GF}^*} \quad \text{GF}$

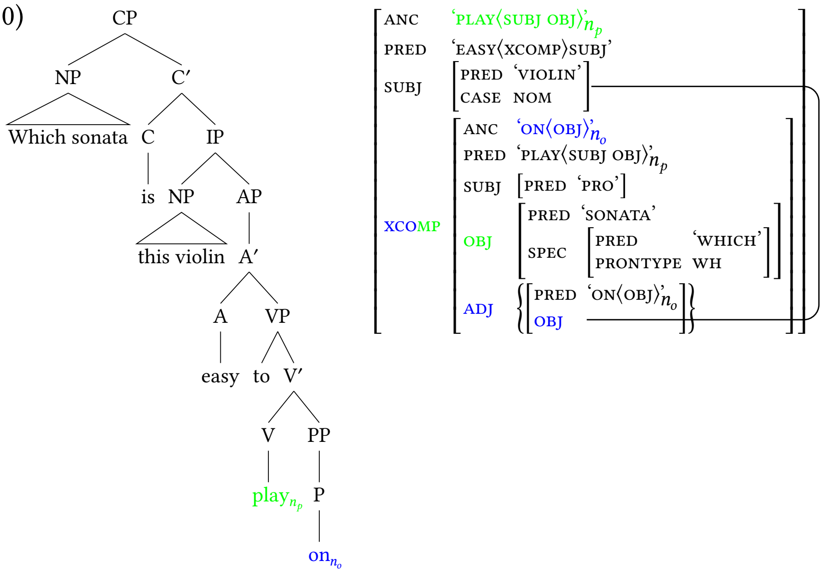
$(\uparrow \text{ ANC})$ is the anchor of the outer uncertainty (*on* in (84a), *play* in (84b)). That remains constant as the uncertainty unfolds. If the outer uncertainty (the *wh* phrase) overlaps an inner uncertainty (*easy*), the ordering condition will compare their two anchors. The nesting follows from the fact that the hierarchical positions of the anchors in f-structure are reversed relative to the linear c-structure order. The nested-order constraint can be imposed (for a language where it applies) by intersecting (88) with the path languages for the various constructions.

The c-structure and f-structures for the nested sentence (84a) are sketched in (89). The attributes and anchor are blue for the outer question dependency and green for the inner *easy* dependency. The outer path overlaps the inner path at the XCOMP of *easy* and then diverges. At that point $(\uparrow \text{ ANC})$ in the question uncertainty denotes the *on* semantic form with source node n_o and the source of $(\rightarrow \text{ ANC})$, the *play* form, is node n_p. The nesting test succeeds because n_o does not precede n_p. For the ungrammatical (84b) the anchors are reversed (90) and the test fails.

(89)



(90)



8 Multiple gap constructions

It is unremarkable in LFG that a given subsidiary f-structure may appear as the values of several attributes at different levels inside a higher structure. This is a consequence of the equality relation in functional descriptions and is the basis for accounts of functional control, agreement, distributed coordination, and the unbounded dependency of *tough* adjectives (and other unbounded dependencies if grammaticized discourse functions are retained in f-structure). Other identities might be consistent with the set of assertions in an f-description, but the linguistically-relevant minimal models contain only those that follow from the basic propositions and the transitivity of equality. This simple picture is violated by the well-known instances wherein a single unbounded-dependency filler appears to resolve to more than one (uncoordinated) within-clause grammatical function (in LFG terms) or somehow binds to more than one trace position (in other frameworks).

Sentence (91) from Engdahl (1983) is a paradigmatic example of such a multiple gap dependency.

(91) Which articles did John file __ without reading __?

This is understood as asking about a particular set of articles that were filed by John but not read by him. The second gap is usually described as "parasitic" on the first because of the contrast in (92) (following the literature, the parasitic gap is now labeled with the subscript *p*).

(92) a. * Which articles did John file the book without reading $\_\__p$?
b. Which articles did John file __ without reading more than their titles?

Example (92a) is ungrammatical for the usual reason that its putative gap is in an island-forming adjunct with respect to unbounded dependencies (in an LFG analysis its FocusPaths uncertainty would not satisfy the path language SAC, the Subject Adjunct Constraint (69)). (91) shows that that barrier is inactive in the presence of the earlier gap, and (92b) shows that resolving to the direct object does not require the support of an adjunct gap.

Multigap dependencies have received relatively little attention in LFG compared to other grammatical frameworks. If an outside-in uncertainty is used to characterize an unbounded dependency, the natural interpretation is that the minimal model for the resulting f-description will establish only one within-clause function for the clause-initial phrase. And even if some technical adjustment is made to allow for multiple function assignments in general, it would still be necessary to account for the fact that the SAC constraint of the normal FocusPaths can be abrogated just in (91) and similar multigap configurations.

Alsina (2008) discusses parasitic gaps in the context of a new general architecture for structure sharing in LFG. On his proposal the f-structure for a sentence is not the minimal model for an f-description derived from the annotations of particular c-structure rules. Rather, the universe of all formally well-formed f-structures, with unlimited structure-sharing relationships, is filtered by a collection of restrictive principles, and the sentence is assigned all and only the f-structures that are not thereby eliminated. As an example, the filter (93a) disallows structure-sharing of an OP and SUBJ at the same level (recall that OP(erator) is the undifferentiating attribute that Alsina uses to represent the filler in f-structure).

(93) Alsina's (2008) "Same-clause OP-SUBJ ban"

a. $^{*}\begin{bmatrix} \text{OP} \\ \text{SUBJ} \end{bmatrix}$

b. For all f-structures f, $(f\ \text{OP}) \neq (f\ \text{SUBJ})$.

A formal expression of this principle is given in (93b). The basic proposition is expressed in the ordinary notation of functional annotations. But this differs from the annotations of the conventional LFG architecture in that the f-structure variable is instantiated by universal quantification over the space of all f-structures and not by mapping particular c-structure nodes through the ϕ correspondence. Alsina (2008) argues that this new architecture and the set of principles he puts forward can provide a unified treatment of bounded (raising) and unbounded dependencies, and that appropriate f-structures can be assigned to sentences with parasitic gaps. This architecture and its principles have not yet been widely adopted, however.

Falk (2011) addresses the multigap problem by an alternative analysis within the conventional LFG architecture. He reasons that if a single uncertainty can license only one dependency and if a sentence has multiple dependencies for one filler, then the f-description for that sentence must have multiple uncertainties. Further, since the number of dependencies in a multigap sentence is determined by the number of within-clause functions assigned to a given filler, the uncertainties for those dependencies must be introduced inside-out at each of the gap locations and not outside-in at the single clause-initial phrase. Thus, he proposes a trace-based, inside-out analysis that freely anticipates any number of unbounded dependencies, even though there may be no local evidence to trigger the empty c-structure nodes. Falk reviews much of the literature on parasitic gaps and other multiple gap constructions, suggesting that many of their restrictions are due to mixtures of pragmatic and processing factors and others are the result of syntactic constraints carried by the inside-out uncertainty paths with their off-path annotations.

The key fact about parasitic gaps is that they are, indeed, parasitic. That fact is not exploited directly by either the Alsina (2008) or Falk (2011) solutions to the multigap problem. In an intuitively straightforward account, an outside-in uncertainty launched at the filler phrase would resolve to the main gap (OBJ in (91)) in the ordinary one-to-one way. But then, optionally, a secondary uncertainty would be launched to bind that same filler also to the grammatical function of the parasitic gap. This is what happens if the PARA path language (94a) is imposed by intersection on the FocusPaths uncertainty (94b).

(94) a. $\text{PARA} = \underset{(\rightarrow\, =\, (\leftarrow\ \ \text{ADJ} \in \text{GF}^{+}))}{\text{GF}^{*}\qquad \backslash\text{SUBJ}}$

b. FocusPaths = [...] & PARA & SAC

If FocusPaths resolves to a non-SUBJ within-clause function, the right arrow → in the optional off-path annotation denotes the top-level filler f-structure. Thus, if the option is taken, this equation launches a new uncertainty that must resolve to some function inside one of the elements of an ADJ set. By virtue of the left arrow ←, that ADJ must be an f-structure sister of the non-SUBJ. The non-SUBJ restriction is included in this example to illustrate one way of accounting for the ungrammaticality of (95); obviously, other factors may also be at work.

(95) * Which articles did you say __ got filed by John without him reading $\_\__p$?
(from Engdahl 1983)

The underlying idea of this solution is that a single filler can be bound to two gaps within an outside-in, one-to-one setting if one uncertainty is allowed to launch another one. The details of an analysis along these lines remain to be developed.

In fact, Falk (2011) notes that parasitic gaps may be a special case of a more general pattern of multiple-gap constructions. Sentences (96b–96c) show that each of the gaps in (96a) can be filled without the support of the other one.

(96) a. Who did you tell __ that you would visit __ ?

b. Who did you tell __ that you would visit your brother?

c. Who did you tell your brother that you would visit __ ?

This pattern can be assimilated to the PARA outside-in off-path solution simply by enlarging the path language of the secondary uncertainty. For this example COMP OBJ would be added as an alternative to the paths beginning with ADJ. There is still an asymmetry between the dependencies for the two gaps: only the primary uncertainty (resolving to the shorter path) is launched from the top, while the secondary one is optionally introduced at the bottom of the first. On this theory what distinguishes adjunct parasitic gaps from other multiple gap examples is just the adjunct island created by the intersection of SAC with the primary path language; that constraint is not incorporated into the secondary uncertainty.[21]

9 Summary

Unbounded dependencies interact in complicated ways with the syntactic properties that define the local organization of clauses and sentences. This chapter provides a sample, clearly incomplete, of the many theoretical and empirical issues that have been discussed in the LFG literature and in the linguistic literature more broadly. The earliest LFG approaches to such dependencies were modeled after the phrase structure solutions of other frameworks, but it is now generally recognized that the functional configurations enshrined in f-structure support the most natural and direct descriptions and explanations. Accounts based directly on f-structure were made possible by extending the basic LFG formalism with the technical device of functional uncertainty.

Functional uncertainty permits the backbone dependencies of topicalization, constituent questions, relative clauses, and the *tough* construction to be stated as regular languages containing the f-structure paths that connect fillers to their within-clause functions. But unbounded dependencies are additionally challenging because they can be sensitive to various features of the f-structures they pass through. The intervening f-structures may be marked in distinctive ways, they may form dependency-blocking islands, and there may be restrictions based on

[21] Further research and consideration of more examples might show that multiple gaps operate symmetrically and that the sequential chaining of secondary uncertainties is therefore inadequate. That would add weight to Falk's (2011) preference for an inside-out solution. Another possibility, indifferent as to inside-out or outside-in, is to extend the interpretation of uncertainty languages in general so that multiple gaps are no longer seen as exceptional:

(i) Multi-gap functional uncertainty
If PATHS is a set of attribute strings and $\varnothing \subset \mathrm{P} \subseteq \mathit{Pref}(\textsc{Paths})$,
$(f\ \textsc{Paths}) = v$ iff $((f\ a)\ \ \mathit{Suff}(a, \textsc{Paths})) = v$ for all $a \in \mathrm{P}$
where $\mathit{Pref}(\textsc{Paths}) = \{a \mid a\sigma \in \textsc{Paths}\}$.
(the set of single-attribute prefixes of strings in PATHS)

A subset P of the available attributes would be selected at each point as an uncertainty unfolds, and the uncertain suffix of each of those attributes must recursively resolve. This is an easy adjustment, technically, but it may be difficult to define path languages so that P subsets properly handle any cross-path interactions.

linear order. This chapter has suggested that many of these ancillary effects can be accounted for by attaching off-path annotations to the uncertainty-path attributes.

In sum, the combination of functional uncertainty with off-path annotations is an expressive tool for describing the rich and varied properties of unbounded dependencies. It integrates well with the other formal devices of LFG theory, and it is the foundation for modern LFG treatments of these phenomena.

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Chapter 5

Raising and control

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Raising and control are classic topics that have had a key role in theoretical debates since the early days of transformational grammar. In this chapter we examine these structural patterns, taking into account cross-linguistic variation and with a particular focus on the way the phenomena in question have been analysed within LFG and the differences between LFG and other theoretical frameworks.

1 The phenomena: raising, control and complementation

The terms RAISING, in reference to the examples in (1), and CONTROL, for those in (2), label different types of relation that may hold between a governing verb and its complement.

(1) a. The teacher seemed to like the students.
    b. The students believed the teacher to like them.

(2) a. The teacher tried to help the students.
    b. The students persuaded the teacher to help them.

On the surface these look very similar: a verb immediately followed by an infinitival complement in (1a) and (2a), and a verb followed by an NP and an infinitival in (1b) and (2b). However, a moment's inspection is enough to reveal fundamental differences. While (2b) does mean that the students persuaded the teacher, (1b) says nothing about whether the students believed the teacher. At the same time in both (1b) and (2b) the NP *the teacher* responds to standard diagnostics for objecthood such as replacement by the pronoun *her/him* and change of

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status to subject under passivization: *The teacher was believed to like the students* and *The teacher was persuaded to help the students*.

Considered from a semantic perspective, the essential difference here is that a raising verb like *seem* does not assign a theta-role to its external argument; rather the acceptability of a sentence with *seem* depends on the semantic compatibility of its external argument and the predicate expressed in the following infinitive. Thus, (1a) is good because *like* requires an animate, sentient being as subject and teacher fills that bill; hence by contrast the unacceptability or pragmatic strangeness of *?The blackboard seemed to like the students*. In this respect, items such as seem show similarities with an auxiliary or a copula like *be* or *become* and indeed they have sometimes been referred to as semi-auxiliaries or semi-copulas (Pustet 2003: 5–6). This intermediate status between a grammatical and a lexical item is often the product of historical change, a topic to which we will return in Section 13 below. By contrast, the external argument of a control (aka equi) verb such as *persuade* or *try* does identify the source of the persuasion or the effort.

Although, in common with much of the literature, we have referred above to *seem* as a raising verb, it would be more accurate to call it a raising predicate since, as has frequently been observed, a particular lexical item may give expression to more than one predicate, not all of which exhibit the same control/raising status. Thus, *appear* is sometimes synonymous with *seem*, as for instance in (3a) beside (1a), but can also occur in other contexts where *seem* is not an option, hence the contrast in grammaticality between (3b) and (3c) and the fact that (3d) is perfectly acceptable while (3e) is at best tautological:

(3) a. The teacher appeared to like the students.
    b. The teacher appeared as if from nowhere.
    c. *The teacher seemed as if from nowhere.
    d. The teacher seemed to appear from nowhere.
    e. ?The teacher appeared to seem to like the students.

In a similar vein, *wants* in (4a) is ambiguous between a reading in which Sally desires to be more diligent and one which expresses her teacher's opinion even if Sally herself has no such wish! The former is a control reading, the latter a raising reading. With a gerundial complement in (4b) only the raising option is available as also in the alternative version in (4c) attested in Scottish and some other varieties of English:

(4) a. Sally wants to work harder.
    b. This shirt wants washing.

c. This shirt wants washed.

More generally, rather than a binary split between raising and control verbs, there appears to be a continuum from raising to control with different verbs in different languages ranged along it (Barron 2001: 75–79, who references an earlier discussion by Huddleston 1976). Such evidence in turn implies the importance of taking into consideration both the syntactic and semantic bases of these constructions as well as language-particular lexical idiosyncrasies. The latter, as we will see, also argue in favour of adopting a diachronic as well as a synchronic perspective.

The terms 'raising' and 'control' both go back to the early years of generative grammar and allude in an interestingly complementary way to the different perspectives that scholars have adopted in analysing examples such as those in (1) and (2). Raising implies a movement from a lower to a higher position within a syntactic representation and thus evokes the derivational type of account that LFG has turned its back on. Control by contrast refers to the relation between a dominant element and a subordinate item or position within a range of non-finite — and indeed, as we will see, some finite — contexts, but with no further implication as to how this relation is to be modelled. In other words, it is part of the more general phenomenon of coreference and identifies a relation which can hold both within complement structures, as above, and in broader syntactic contexts as in the examples in (5):

(5) a. Glad to be home again, Sally waved to her neighbours in the garden.
b. Bill called a plumber to fix the drain.
c. Sally came across Bill in the garden crying his eyes out.

In (5a) the argument that *glad* is predicated of can only be Sally and not her neighbours but the relation is determined by the clausal structure and not by any specific lexical item; in (5b) we have an optional purpose clause added to the main clause *Bill called a plumber*; in both (5b) and (5c) the modifying clauses *to fix the drain* and *crying his eyes out* are controlled by the object of the main clause. Cases such as these fall under the heading of adjunct control, a topic which we consider in more detail in Section 12 below.

The literature on these constructions, and possible analyses thereof, is vast (see Davies & Dubinsky 2004 and Landau 2013 for book-length treatments and Polinsky 2013 for a briefer but no less valuable survey), and there is now a very thorough and up-to-date account in LFG terms in Dalrymple et al. (2019: chapter 15). It is natural then to ask what more a chapter such as the present one can bring to the table. Rather than simply serving up yet another overview, we will concentrate instead on three themes, in each case seeking to show the advantages — and in some instances the problems — inherent in adopting an LFG perspective:

1. cross-linguistic and diachronic variation in control/raising structures;
2. proposals that post-date the surveys cited above, in particular the 'two-tier' model put forward in Landau (2015), the analysis of so-called restructuring verbs (Grano 2015), the treatment of partial control (Pearson 2016, Sheehan 2018a,b, Sevdali & Sheehan 2021), and the treatment of adjunct control (Donaldson 2021a,b, Landau 2021);
3. cross-theoretical comparison of LFG with other approaches, in particular on the one hand derivational accounts within versions of Minimalism and on the other the lexical semantic approach of Jackendoff & Culicover (2003) and Culicover & Jackendoff (2006).

That said, some foundations need to be laid. We begin therefore by reviewing a series of dichotomies and sub-types that have served to frame much of the literature to date (Section 2 through Section 5) before moving on to consider our chosen themes and their theoretical implications.

2 Functional vs anaphoric control

Differences of detail and interpretation aside, LFG analyses of these items and constructions all build on the classic distinction between functional and anaphoric control developed in Bresnan (1982a) and other early LFG work on the topic such as Mohanan (1983). Functional control involves identity between a controlling grammatical relation and an open function, XCOMP in the case of control induced by lexical items and XADJ for adjunct control. Crucially, on Bresnan's account functional control provides a means of modelling both verbs traditionally labelled as raising and equi, as can be seen in the f-structures for *seem* and *try* in (6):

(6)	a. *seem*	V	(↑ PRED) = 'SEEM⟨XCOMP⟩SUBJ' (↑ SUBJ) = (↑ XCOMP SUBJ)
	b. *try*	V	(↑ PRED) = 'TRY⟨SUBJ,XCOMP⟩' (↑ SUBJ) = (↑ XCOMP SUBJ)

These representations distinguish the raising verb *seem*, where the SUBJ is outside the brackets which enclose the semantically pertinent arguments, from the equi verb *try*, where all the arguments are inside. Otherwise put, *try* assigns a theta-role to its subject while *seem* does not.

The open XCOMP function has also been proposed as a way of modelling some copular and auxiliary constructions (Falk 1984). Thus in Maltese, where there is no copula in the present tense as in (7a) by contrast with the past (7b), one solution is to allow the PRED value 'BE⟨XCOMP⟩SUBJ' to be assigned either to the copula or, in its absence, to the predicate nominal. In effect, this treats these constructions as a type of raising.

(7) Maltese

a. Albert tabib
   A. doctor
   'Albert is a doctor.'

b. Albert kien tabib
   A. be.PST.M.SG doctor
   'Albert was a doctor.'

The alternative here, and one perhaps more consistent with traditional accounts of copulas as items that connect subjects and predicates of various grammatical kinds, would involve the closed function PREDLINK and a copula with the PRED value 'BE⟨SUBJ,PREDLINK⟩' (for more discussion of these options and the conclusion that no single account will cover all cross-linguistic copular patterns, see Dalrymple et al. (2019: 189–197)).

A further possibility, which we will not discuss here, is to permit control into some object and oblique structures, an account that involves postulating open variants XOBJ and XOBL of the standard closed functions OBJ and OBL (Falk 2005).

In contrast to these lexically determined structures, an example like (5a) requires a statement of the relational equivalence within the relevant PS rule rather than as part of the lexical entry:

(8) $$\text{IP} \longrightarrow \begin{array}{c}\text{AP}\\ (\uparrow \textsc{xadj}){=}\downarrow\\ (\uparrow \textsc{subj}){=}(\downarrow \textsc{subj})\end{array} \quad \begin{array}{c}\text{IP}\\ \uparrow{=}\downarrow\\ \ \end{array}$$

In this way an adjunct phrase (AP) such as *glad to be home again* is marked as serving the XADJ role within the f-structure of the higher IP and the open subject of the XADJ will be determined at the level of the clause rather than by a specific lexical entry.

The common property in both the XCOMP and XADJ constructions is identity between the controlling and the controlled function, which means not only that the items in question must be coreferential but that they must share all grammatical and semantic features such as case, gender, number and person. They also have in common that in some contexts they may alternate with closed functions. Thus, the examples (9a) and (9b) illustrate a closed COMP *that*-clause subcategorised by verbs like *believe* and *promise*, while in (10a) and (10b) we have instances of closed ADJ as the function to be associated with the constituents *everyone having gone home* and *with Sally away*:

(9) a. The doctor promised Sally that the medicine would work.
 b. Sally believed that the doctor was right.

(10) a. Everyone having gone home, Bill could finally relax.
 b. With Sally away, the house seemed very quiet.

Examples such as those in (9) and (10) are closed functions with independently defined subjects. However, it is also possible for a closed COMP to have a controlled subject, as in (11) and (12).

(11) a. Losing the race upset Bill.
 b. Bill and Sally discussed complaining to the teacher.

(12) a. Bill prefers to leave now.
 b. Bill wishes to leave tomorrow

In such a circumstance, in order to establish a link between a controller and a controlled item within a closed function we need anaphoric control. As the name implies, this involves an element, labelled PRO, which behaves like a pronoun in its ability to establish a referential link to an item outside the constituent that it is part of, but, like overt anaphors such as reflexives and unlike pronouns, it does not have the ability to refer independently. Formally, what this involves is the rule in (13) (= (35) in Bresnan 1982a: 326), where G identifies the universal set of semantically unrestricted functions and Δ allows for particular limitations on the available function in any given language:

(13) For all lexical entries L, for all G $\in \Delta$, assign the optional pair of equations $\{((\uparrow \text{G PRED}) = \text{`PRO'}, (\uparrow \text{FIN}) =_c \alpha\}$ to L.

This general principle allows the PRO-valued function to be assigned to lexical entries while respecting language particular constraints as to what may constitute the function G and what set of forms it can apply to. Thus, in English G can only be SUBJ and the forms in question must be non-finite but, as we shall see, other languages may vary. This rule is applicable both for predicates with no overt subject such as *losing the race* in (11a) or *complaining to the teacher* in (11b) and for the complements of some verbs, particularly those of wishing and wanting, as in (12). We return to the special issues engendered by the analysis of these verbs in Section 4 below.

The difference between verbs that take functional control and those that take anaphoric control is very clear in Icelandic (Andrews 1982, 1990), a language in which some items display subject properties such as determination of reflexives but where the case marking is not the usual nominative. Thus, in the simple sentence (14a) the subject of *gengur vel* 'do well' is marked with the dative case. When this predicate is embedded under a functional control verb as in (14b) the dative case is maintained but with an anaphoric control verb as in (14c), for many speakers, it is the latter item that determines the nominative case on the subject (examples from Andrews 1990: (39) and (43)):

(14) Icelandic

a. Drengnum gengur vel við vinnuna
boy.DEF.DAT go.PRS.3SG well at work
'The boy is doing well at work.'

b. Drengnum virðist ganga vel við vinnuna
boy.DEF.DAT seem.PRS.3SG go.INF well at work
'The boy seems to be doing well at work.'

c. Drengurinn vonast til að ganga vel við vinnuna
boy.DEF.NOM hope.PRS.3SG C INFL go.INF well at work
'The boy hopes to do well at work.'

To model (14c) requires a lexical entry for *vona* 'hope' as in (15):

(15) *vona* V (↑ PRED) = 'VONA⟨SUBJ,COMP⟩'
(↑ COMP SUBJ PRED) = 'PRO'

Where the presence of PRO is determined by the lexical entry, as here, we have an instance of obligatory anaphoric control. By contrast in (16) we have so-called arbitrary control where the antecedent for PRO depends not on the requirements of the matrix verb but on the broader context.

(16) a. Bill gestured but nobody noticed it.
b. Bill gestured to leave.
c. Bill gestured for everyone to leave.
d. Sally said everyone thought Bill should have gestured (for them/her) to leave.

A verb like *gesture* does not require a complement, as (16a) demonstrates. However, if it is linked to an infinitive, then the external argument of the infinitival verb can either be implicit and dependent on the discourse situation, as in (16b), or be made explicit, as in (16c). Moreover, if there is an overt antecedent it may be two or more clauses earlier as in (16d).

It is important to underscore that while, as we have already said, labels like raising and control verb or construction are commonly used to classify empirical phenomena, the distinction between functional and anaphoric control is a theoretical construct designed to model such data. It is eminently possible, therefore, that within LFG as within other frameworks, there could be different analyses for the same dataset. Thus, for the verb *try* Bresnan's lexical entry in (6b) implies an analysis in terms of functional control, endorsed in Mohanan (1983: 644) and repeated in Börjars et al. (2019: 103). Similarly, Falk (2001: 141–144) argues for a distinction between *try* with functional control and verbs like *agree* with anaphoric control. By contrast, Dalrymple et al. (2019: 561–566), and already Dalrymple (2001: §4.2), prefer to analyse *try* as also requiring obligatory anaphoric control and hence with the PRED value in (17) akin to the one for Icelandic *vona* in (15):

(17) *try* V (↑ PRED) = 'TRY⟨SUBJ,COMP⟩'
(↑ COMP SUBJ PRED) = 'PRO'

This has the benefit of allowing a much closer alignment between the traditional classes and the different analyses, with raising coming under functional control and equi verbs under anaphoric control. It has consequences, too, when we come to consider the semantics of control/raising since a COMP translates naturally into a proposition whereas the obvious semantic correlate of an XCOMP is a property. Moreover, it serves to undermine one of the criticisms of LFG made by Landau (2013: 61–62) following Davies (1988), namely that functional control is not relevant for phenomena which traditionally fall under the heading of control. But this depends on the analysis not the framework. Landau rightly goes on to observe, as others have done, that in this respect the LFG account exhibits parallels with the movement theory of control advanced by Hornstein and colleagues

(Hornstein 1999, Hornstein & Polinsky 2010): they move everything, Bresnan moves nothing! But once again this is a matter for debate within the frameworks in question not one for *a priori* prescription. What is clear is that more than one analytic device is required to encompass the full range of empirical phenomena both within and across languages.

It should also be emphasised that within LFG neither functional nor anaphoric control requires the postulation of anything more than a VP at the level of c-structure in stark contrast to the FinPs, ForcePs, TPs, vPs and the like which populate the syntactic trees assigned to these constructions within derivational/configurational analyses, regardless of the finiteness of the complement.

We return to the question of the relation between finiteness and control/raising in Section 6 and to issues concerning the appropriate semantic analysis in Section 10.

3 Obligatory vs non-obligatory control

The distinction between obligatory (OC) and non-obligatory control (NOC) goes back to Williams (1980); since then there has been considerable discussion about where and how to draw the boundary between them. The crucial differences, as set out by Williams (1980: 208–209), are that in cases of OC the PRO cannot be replaced by an overt lexical item and must have a grammatically determined antecedent. Hence the general agreement that raising constructions fall within the territory defined as OC while the PROs in examples such as those in (18) require NOC.

(18) a. It is not possible [PRO to open the window].
  b. [PRO forgetting his own birthday] is typical of Bill.

Where other types of control are to be placed and how they are to be modelled are by contrast still matters for debate. There is, for example, a close match between Williams's (1980) dichotomy and the distinction between functional and anaphoric control as originally formulated in Bresnan (1982a), although even then the two are not equivalent (*pace* for example Landau 2013: 241). Since that time, however, there has been general agreement that anaphoric control for desiderative verbs for example must fall within OC. In order to get the discussion going, therefore, we need criteria to delimit these empirical domains, and to that end we will adopt what Landau (2013: 29) calls the OC 'signature' and which he defines as in (19) (= his (74)):

(19) In a control construction [… X_i… [$_S$ PRO$_i$…]…], where X controls the PRO subject of the clause S:

a. The controller(s) X must be (a) co-dependent(s) of S

b. PRO or part of it must be interpreted as a bound variable.

NOC is then defined as anything which does not meet these criteria. Alternatively, and more positively, NOC covers control into subject and adjoined or extraposed clauses (Landau 2013: 38, (96)) and, if we follow Landau (2020), also for some classes of lexical predicates. We return to the issue of NOC in Section 11 when we discuss Landau's two-tier model.

4 Exhaustive vs partial control

Within the broader domain of OC there is a sub-type that has generated special interest, namely the phenomenon that has come to be called partial control (PC). We have already observed that in one reading of an example like (4a) — repeated here as (20a) — the subject of *want* can be in a control relation to the unexpressed subject of its infinitival complement: Sally is both the source of the desire and the one who will work.

(20) a. Sally wants to work harder.

b. The chair wanted to meet without me.

c. Morten wants to leave the European Union.

In (20b), on the other hand, the subject of the infinitive includes, but is not simply coreferential with, the subject of *want*. Rather, the embedded verb *meet* requires a semantically plural subject, as is clear from the ungrammaticality of (21a) but nonetheless can occur as the complement of *want* even when the subject of *want* is singular. Similarly, while (20c) is fine as an expression of Morten's political ambition for the country he belongs to, (21b) describes an odd state of affairs since membership of an organization like the EU is not a matter for individual decisions or efforts.

(21) a. *The chair met.

b. #Morten tried to leave the European Union.

At the same time, the semantic plurality of the implicit subject does not trigger morphosyntactic plurality for all speakers. Thus, (22a) is fine while the uncontrolled (22b) fails. (22c) is unproblematic because both *Sally* and *herself* are singular whereas American English speakers do not readily accept the plural *by* *themselves*, as in (22d), unless the infinitival clause contains a plural subject as in (22e) (Landau 2013: 161).

(22) a. Sally wanted to work together.
b. *Sally worked together
c. Sally wanted to work by herself.
d. ?Sally wanted to work by themselves.
e. Sally wanted her and Bill to work by themselves.

Given the way the PC effects depend on the choice of governing verb, it follows from the principle in (19) that partial control must be a sub-type of OC. This conclusion is accepted by Asudeh (2005), who proposes an analysis combining f-structure and glue semantics as in (23) for the exhaustive control *try* and (24) for the partial control *want*:

(23) $\lambda x.\lambda P.try(x, P(x)) : (\uparrow \textsc{subj})_\sigma \multimap [(\uparrow \textsc{xcomp subj})_\sigma \multimap (\uparrow \textsc{xcomp})_\sigma] \multimap \uparrow_\sigma$

(24) $\lambda x.\lambda P.\exists y.want(x, P(y)) \wedge x \sqsubseteq y) :$
$(\uparrow \textsc{subj})_\sigma \multimap [(\uparrow \textsc{xcomp subj})_\sigma \multimap (\uparrow \textsc{xcomp})_\sigma] \multimap \uparrow_\sigma$

Here is not the place to go into the technical details of the glue analysis. The crucial difference is that while the analysis of *try* in (23) maps directly onto the f-structure representation in (6b), the analysis of *want* introduces an additional variable y, which can either be equivalent to x or identify a superset of which x is necessarily a member. In other respects (24) is a straightforward instance of functional control. However, as Haug (2013) notes, this gives the wrong result with quantified examples like (25) (= Haug's (29)):

(25) Everybody wanted to have lunch together.

The most natural reading of this is the collective one in which *everybody* and *together* refer to the same set of individuals, whereas the representation in (24) implies a distributive reading in which for each member of the set identified by *everybody* there is a different, not necessarily overlapping, group of people (s)he wants to lunch with.

In consequence, Haug proposes an alternative analysis involving what he calls 'quasi-obligatory anaphoric control'. Such items are distinguished from contexts of arbitrary control by virtue of a locality constraint imposed by the controlling predicate but, unlike with obligatory control verbs, the constraint is semantic and not syntactic. We will not go here into the formal details of his analysis (for which see also Haug 2014), but note simply that if these proposals are adopted, we end up with a typology of control that allows the four options set out in Table 1. Crucially, such a typology creates a de facto continuum from syntax through to discourse-determined structures rather than reducing all patterns to syntactic configurations.

Table 1: Typology of control (Haug 2013: 61)

	f-control	obligatory a-control	quasi-obligatory a-control	arbitrary a-control
locality	syntactic	syntactic	semantic	discourse
identity	+	–	–	–

Table 2: An LFG typology of control (Szűcs 2018b: 359)

CONTROL-TYPE			Example
Thematicity of controller	Nature of identification	Finiteness	
Equi (thematic)	anaphoric identification	finite complement	prolepsis
		non-finite complement	canonical control (“*agree*-type”)
	functional identification	finite complement	Turkish object control (?)[a]
		non-finite complement	canonical control (“*try*-type”)
Raising (non-thematic)	anaphoric identification	finite complement	not expected
		non-finite complement	not expected
	functional identification	finite complement	copy raising/ hyper-raising[b]
		non-finite complement	canonical raising

[a]Turkish is here cited as a further example of control into finite clauses of the kind discussed with reference to a number of other languages in Section 6 below.

[b]The term ‘hyper-raising’ is taken from Carstens & Diercks (2013) and refers to structures that are in all relevant respects parallel to copy raising (on which see Section 9 below) but where the embedded finite clause has a covert rather than an expletive subject. See Zyman (2023) for further discussion and assessment of analyses within the framework of Minimalism.

Similar in spirit, though structurally more wide-ranging, is the LFG-based typology of control proposed in Szűcs (2018b) as in Table 2. The new data that is here incorporated into the typology is what Szűcs calls 'prolepsis' as exemplified in Hungarian examples such as (= his 1b):

(26) Hungarian

Janós(-t)	mondtad	hogy	jön	a	partira
John(-ACC)	say.PST.2SG	C	come.PRS.3SG	the	party.onto

'(Of) John, you said that he is coming to the party.'

The fronted argument *Janós* is optionally marked with accusative case. Szűcs takes this as evidence that it is an optional argument of the verb *mond* 'say' which therefore has a possible PRED value ⟨(SUBJ)(OBJ)(COMP)⟩. He draws a parallel here with English examples like *I read of Carol that she was awfully shy*, a type of structure that has received little or no attention in the literature to date. The relation of prolepsis to control has been taken up more recently by Landau (2021: Â§14.4.5) though without any reference to Szűcs' contribution.

A different strategy for subsuming raising, but not control, within a broader set of constructions is the concept of structure-sharing developed by Alsina (2008, 2010). On this view, what raising shares with long distance dependencies (topics and wh-questions) and parasitic gap constructions is a governing and thematically unrestricted function which is shared with the embedded argument slot. There is not space here to go into the full details of Alsina's proposals but the overall logic is similar to that of Szűcs, namely that there are shared properties of argument and pronominal constructions that need to be captured in an appropriate formal way, building on functional rather than categorial structure.

Noteworthy, too, is the fact that in a model such as Simpler Syntax, which goes further than LFG in the direction of reducing syntactic operations and structures to a minimum, one area where functions rather than configurations play a key role is precisely raising and control (Culicover & Jackendoff 2019: §3.3).

It is instructive to compare these approaches to syntax-centred ones such as those advanced in recent derivational work. Thus, Sheehan (2014) argues for the presence of a non-overt comitative argument in order to account for the extra participant(s) implicit in examples such as (20b), an analytic strategy akin to that proposed by Asudeh (2005) but with the added variable inserted in the syntax rather than the semantics. This, however, is open to the same objections as raised by Haug and is challenged on its own theoretical terms by Landau (2016). Alternatively, as argued in Sheehan (2018b) and Sevdali & Sheehan (2021), the differences between exhaustive and partial control can be attributed to the syntactic constructs Agree and Case, neither of which are available — or indeed needed — within the theoretically more economical framework of LFG.

5 Split and implicit control

Partial control needs to be distinguished from two further subtypes, namely split control as exemplified in (27) and implicit control as in (28):

(27) John$_i$ discussed with Mary$_j$ [which club PRO$_{i+j}$ to become members of].

(28) a. It was fun to visit the new museum.
b. It was not permitted to cross the track.

In the former the antecedents are divided between the arguments of the verb, so that *members* in (27) must refer back jointly and exhaustively to John and Mary. As Landau notes, this phenomenon does not fall readily under any of the existing approaches and he concludes that at the time of writing 'there is no satisfactory theory for the syntax of split control constructions' (Landau 2013: 174). This may of course be because the pattern is not inherently syntactic but falls within the semantic/discourse domain of Haug's typology. Such a conclusion is reinforced by the fact that it is particularly attested in Japanese and Korean in the context of exhortative marking as in the Korean example (29) (= Landau's 328b):

(29) Korean
Chelsu$_i$-ka Hwun$_j$-eykey [PRO$_{i+j}$ ilbon umsik-ul mek-ca-ko
Chelswu-NOM Hwun-DAT Japan food-ACC eat-EXH-C
mal-ha-yess-ta]
tell-do-PST-DECL
Lit. 'Chelswu said to Hwun to eat Japanese food together.'

This reports a suggestion ('let's eat together') though it is not direct speech but the presence of the exhortative marker *-ca* on the verb licenses the split control. Similarly, the Japanese minimal pair in (30) (adapted from example (38) in Fujii 2010) shows that when the exhortative particle *-(y)oo-* is present there can be split control while with the imperative particle *-e-* the examples are ungrammatical:

(30) Japanese

a. *Taro-wa Hiroshi-ni [PRO otagai-o sonkeesi-a-e-to]
Taro-TOP Hiroshi-DAT each.other-ACC respect-RECP-IMP-C
itta/meireisita
say/order.PST
'Taro said to/ordered Hiroshi that they should respect-IMP each other.'

b. Taro-wa Hiroshi-ni [PRO otagai-o sonkeesi-a-oo-to]
Taro-TOP Hiroshi-DAT each.other-ACC respect-RECP-EXH-C
it-ta/teiansita
say/propose.PST
'Taro said/proposed to Hiroshi that they should respect-EXH each other.'

In other words, it is the nature of the speech act rather than the syntactic configuration that licenses the split control effect.

Implicit control, as in (28), is in a way the direct opposite since there is no overt antecedent for the infinitival complements. In the literature, and following Bresnan (1982a), this has been linked to the so-called Visser's generalization (VG) which states that subject control verbs cannot be passivized and which is claimed to explain the ungrammaticality of examples like (31a,31c) (= 86c,e from Bresnan 1982a):[1]

(31) a. *She was failed (by Max) as a husband.
b. Max failed her as a husband.
c. *Frank was promised to leave (by Mary).
d. Mary promised Frank to leave.

Examples such as these led Bresnan to propose as a general principle that controllers must be overt and occupy a semantically unrestricted grammatical function such as SUBJ or OBJ. However, while this may be true for English, it does not necessarily hold cross-linguistically as the grammaticality of the following Dutch (32) and German (33) examples and the ungrammaticality of their literal English translations — taken from the discussion in Wurmbrand (2021) — attest:[2]

[1] In the literature VG is often accompanied by something labelled Bach's generalization (BG) — see for example Dalrymple et al. (2019: 586) — but as Landau (2013: 179–179) notes the empirical basis for BG has been challenged and we will not discuss it further here.

[2] Here and elsewhere in the glosses, to avoid confusion, we use C to label the category complementizer as opposed to the function COMP, although in the general literature and as recommended in the Leipzig conventions COMP is regularly used as a gloss for complementizer.

(32) Dutch
Er werd mij beloofd/aangeboden om me op de hoogte te houden
There be.PST I.DAT promise/offer.PST.PTCP C I.DAT on the height to keep.INF
'It was promised/offered to keep me informed.'

(33) German
Mir wurde versprochen mir noch heute den Link für das Update zu schicken
I.DAT become.PST promise.PST.PTCP I.DAT still today the link for the update to send.INF
'It was promised to me to send me the link for the update today.'

In the light of such data, van Urk (2013) proposes what has come to be called (Landau 2013: 182) the restricted VG as in (34):

(34) Implicit subjects cannot control if T agrees with a referential DP.

More recent cross-linguistic investigation of the phenomenon is reported in Pitteroff & Schäfer (2019) and Wurmbrand (2021) offers a formal account within a Minimalist framework. Within LFG, data of this kind can be handled within the framework developed by Haug (2014), as noted by Reed (2020: 13–16) in her discussion of Landau's two-tier approach, although she herself offers yet another Minimalist account.

6 Control and finiteness

Much, if not most, of the literature dealing with the theory of control has focussed on English but, as we have already seen on more than one occasion, contrasting patterns from other languages shed new light on the phenomena and the way that they can be modelled. The English data that was at the heart of early debates focuses almost exclusively on infinitival constructions, but, as Haspelmath (2013) demonstrates, English is unusual in admitting infinitival clauses both with and without subjects co-referential to the subject of the controlling predicate as in the minimal pair *I want to leave* vs *I want Bill to leave*. In this section we review some of the typological diversity focussing in particular on finite vs non-finite splits (Italian, Danish, Hungarian), control into finite clauses (as in Greek, Romanian, Chinese and Japanese), and the special case of inflected infinitives (as in Portuguese and Sardinian).

We begin then with the finite/non-finite alternation seen in the following Italian examples:

(35) Italian

a. Giorgio vuole partire domani
   G. want.PRS.3SG leave.INF tomorrow
   'George wants to leave tomorrow.'

b. Giorgio vuole che Paolo parta domani
   G. want.PRS.3SG C P. leave.PRS.SBJV.3SG tomorrow
   'George wants Paul to leave tomorrow.'

The pattern here is clear: infinitival clause when there is co-reference between the subject of the governing verb and the embedded predicate, finite (and subjunctive) clause when the subjects differ. In LFG terms the functional structure of the 'want' verb is constant — 'VOLERE⟨SUBJ,COMP⟩' — but the syntactic realizations differ. Since it is the f-structure that feeds into the semantics there is no need to create parallel c-structures as would be required in frameworks where the configurational syntax drives the semantics.

The Danish examples in (36) work in similar fashion but with an extra dimension of complexity:

(36) Danish

a. Georg vil gerne tage af sted i morgen
   G. want.PRS with-pleasure go.INF from place in morning
   'George wants to leave tomorrow.'

b. Georg vil gerne *(have) at Paul tager af sted i morgen
   G. want.PRS with-pleasure have.INF C P. go.PRS from place in morning
   'George wants Paul to leave tomorrow.'

c. Georg vil gerne *(have) æg til morgenmad
   G. want.PRS with-pleasure have.INF egg.PL for breakfast
   'George wants eggs for breakfast.'

The translation of 'want' is *vil gerne*, literally 'will with pleasure', and in (36a), parallel to both the Italian (35a) and the English translation, in the coreferential construction it governs an infinitive. In (36b), on the other hand, when there are distinct subjects, the embedded clause is finite but there is an intervening infinitive of the verb *have* 'have'. This same additional ingredient is required when the 'want' verb takes a nominal object as in (36c); both these examples are ungrammatical if *have* is omitted, whereas (36a) is ungrammatical if *have* is inserted.

At first sight the Danish data would appear to support the analysis of the syntax of 'want' verbs proposed in Grano (2015: 83), according to which the structures which underly the various uses of English *want* are as in (37):

(37) a. John wants [$\varnothing_{have}$ an apple].
b. John wants [VP to stay].
c. John wants [VP $\varnothing_{have}$ [vP Mary to stay].
d. John wants [VP $\varnothing_{have}$ [vP PRO to stay].

The key part of this analysis, building on Cinque (2004), is that English *want* is not treated as a full-fledged independent lexical item but rather as an item which occupies a functional head in the modal domain. When it appears to be transitive, as in (37a), it is because it is accompanied by a silent transitive HAVE which licenses the direct object. The same would hold for the equivalent Italian *Giovanni vuole una mela*. Danish then differs from English and Italian simply in virtue of the HAVE item being overt.

It follows, too, that if *want* sits in a functional position, an example like (37b) is monoclausal. This is supported by Italian examples like (38) where the clitic object can either attach to the modal 'want' or to the main verb:

(38) Italian
a. Giovanni vuole mangiar=la
G. want.PRS.3SG eat.INF=it
b. Giovanni la=vuole mangiare
G. it=want.PRS.3SG eat.INF
'Giovanni wants to eat it.'

Strikingly, this so-called clitic climbing, standardly taken as evidence of restructuring from a bi- to a mono-clausal configuration, is for many speakers not permitted in PC contexts like (39):[3]

(39) Italian

[3]Native speaker judgements here are mixed with some speakers accepting both and some neither! However, for the majority (39a) is acceptable while for (39b) even those who accept it prefer a rephrasing with a finite clause *che ci incontrassimo* 'that we should meet each other'.

a. Giovanni vuole incontrar=si domani
G. want.PRS.3SG meet.INF=RECP tomorrow

b. *?Giovanni si=vuole incontrare domani
G. RECP=want.PRS.3SG meet.INF tomorrow
'Giovanni wants to meet tomorrow.'

In short, exhaustive control is monoclausal and partial control is biclausal, but with the biclausality in the latter licensed not by the *want* verb but by the silent HAVE, in a structure parallel to that postulated for the English (37d). There are, however, two problems with this analysis. First, precisely in the partial control context Danish does not permit *have*, and second in no other context in English, Danish, Italian and many other languages do *have* verbs license finite clausal complements. Grano seeks to avoid this latter charge by analysing the complement of the silent HAVE as a vP rather than the CP that Cinque had proposed but, given that the Italian item *che* in (35b) and the Danish *at* in (36b) are the default complementizers used in a wide range of embedded clauses types, this way out of the dilemma lacks conviction. The best alternative, therefore, would appear to involve a syntax or c-structure based on whatever overt categories are attested in the different languages linked to a more cross-linguistically robust f-structure and a syntax-semantics constructional hierarchy of exactly the kind set out in Table 1 above.

A more radical LFG alternative on the f-structure side, though one still consistent with the Haug hierarchy, would be to collapse COMP and OBJ as proposed for Hungarian *akar* 'want' by Szűcs (2018a):

(40) Hungarian

a. Kati ételt akar
K. food.ACC want.PRS.3SG
'Kati wants food.'

b. Kati enni akar
K. eat.INF want.PRS.3SG
'Kati wants to eat.'

c. Kati akarja hogy együnk
K. want.PRS.DEF.3SG C eat.SBJV.1PL
'Kati wants us to eat, lit. that we eat.'

d. Kati ételt és azzal jóllakni akar
K. food.ACC and it.with satisfied.become.INF want.PRS.3SG
'Kati wants food and to be satisfied with it.'

This verb displays the same patterns of simple transitivity and an alternation of finite and infinitival complements as Italian and Danish. Given that the nominal and clausal arguments may be co-ordinated as in (40d), Szűcs argues that the most economical account involves a single lexical predicate structure, namely ⟨(subj)(obj)⟩. He does not consider the PC option, but there is no reason to believe that this would undermine or alter his argument.

A different type of pattern is found in various languages belonging to the so-called Balkan *Sprachbund* such as Greek and Romanian, in some southern Italian dialects and in Japanese and Korean, where the complements can be finite regardless of whether there is coreference or not. Thus in Greek we have:

(41) Greek

a. thelo na liso to provlima
want.prs.1sg prt solve.prs.1sg the problem
'I want to solve the problem.'

b. O Kostas theli na odhiji
the K. want.prs.3sg prt drive.prs.3sg
'Kostas wants (her/him) to drive.'

In (41a) both the controlling verb and the embedded verb are finite first person singular despite the fact that they refer to the same subject. It follows that if both verbs are third person singular as in (41b), they can either co-refer (Kostas wants to be the driver) or have different referents (Kostas wants someone else to drive). A similar ambiguity can be seen in the Korean example (42) (Lee 2009: 112):

(42) Korean
Mina-ke hakkyo-ey ka-nun kes-ul para-yess-ta Wujin-to
M.-nom school-loc go-adn thing-acc want-pst-decl W.-also
kuli-ha-yess-ta
so-do-pst-decl
'Mina wanted to go to school and so did Wujin.'

This can mean either that Mina wanted to go to school and Wujin also wanted to go to school himself or that Wujin also wanted Mina to go to school.

In all these languages there are restrictions on the tense or mood of the embedded predicate which space prevents us from going into here. However, the general principle is clear: the overt syntax does not map one-to-one onto the semantic ingredients so that either the syntax has to be rendered more semantically transparent via the use of functional and null heads and syntactic movement, or the configurational syntax is held constant and the burden is shifted to other levels. The use of f-structure and s-structure clearly goes down this latter route; see Sells (2007) and Polinsky (2013) for general discussion.

Another difference across languages concerns the realization of the PRO item. While this is standardly taken to be a silent category, Satik (2021) argues that in the Anlo dialect of the Niger-Congo language Ewe the pronoun *yè* in the examples in (43) (= his (5a)) exhibits the properties of an overt PRO (POT in his gloss stands for 'potential'):

(43) Ewe (Anlo dialect)
Agbei dzagbagba/ŋlobe/dzina/vɔvɔm/wosusu/dzi/susum be yèi-a dzo
A try/forget/want/afraid/decide/like/intend C YÈ-POT leave
'Agbei tried/forgot/wanted/is afraid/decided/likes/intends PRO$_i$ to leave.'

Satik goes on to develop a Minimalist-inspired analysis of the Anlo data which we will not discuss in the present context. It suffices for our purposes to note that, as he also argues, the existence of languages with overt PRO serves to disconfirm the movement analysis of control alluded to at the end of Section 2, since movement would always leave an empty and not an overt trace. This conclusion is reinforced by languages where the item in the expected PRO slot is a full NP, as in the Zapotec example in (44) cited by Polinsky & Potsdam (2006) as an instance of what they call copy control (= their (22a)):

(44) Zapotec
rcàäa'z Gye'eihlly g-auh (Gye'eihlly) bxaady
HAB-want Mike IRR-eat (Mike) grasshopper
'Mike wants to eat grasshopper.'

They further note that while the full NP is optional, a pronominal subject in the controlling clause would obligatorily determine an overt matching pronoun in the controlled clause, akin therefore to the Anlo example in (43).

Yet another type of alternation is to be seen in the contrast between bare and inflected infinitives in Portuguese and several other Romance varieties. Thus, consider the examples in (45):[4]

(45) European Portuguese

[4]It is important to note that the examples in this section are drawn from European Portuguese (EP) since Brazilian and other varieties exhibit significant differences in relation to these constructions (Madeira & Fiéis 2020). There are similar patterns to EP in the closely related Galician (Sheehan et al. 2020).

a. Serà dificil (eles) aprovar-em a proposta
be.FUT.3SG difficult (they) approve-INF.3PL the proposal
'It will be difficult for them to approve the proposal.'

b. Eu lamento (eles) terem trabalhado pouco
I regret.PRS.1SG (they) have.INF.3PL work.PST.PTCP little
'I regret that they have worked very little; lit. them to have worked.'

In (45a) the embedded infinitival complement *aprovarem* bears the third person plural suffix, as does the perfect auxiliary terem in (45b). This same suffix occurs on the finite form *parecem* 'they seem' in the raising context of (46b) but in that context cannot be added to the embedded infinitive, hence the ungrammaticality of (46c).

(46) European Portuguese

a. parece que os organizadores adiaram o congresso
seem.PRS.3SG C the organizer.PL postpone.PST.3PL the conference
'It seems that the organizers have postponed the conference.'

b. Os organizadores parecem ter adiado o congresso
the organizer.PL seem.PRS.3PL have.INF postpone.PST.PTCP the conference
'The organizers seem to have postponed the conference.'

c. *Os organizadores parecem terem adiado o congress
the organizer.PL seem.PRS.3PL have.INF.3PL postpone.PST.PTCP the conference

With control verbs we find a significant difference between exhaustive and partial control (examples from Madeira & Fiéis 2020: 429):

(47) European Portuguese

a. Prefer-ias chegar(*es) a tempo
prefer-IND.IPFV.2SG arrive.INF (*2SG) on time
'You would prefer to arrive on time.'

b. O João prefer-ia reunir(%em)-se mais tarde
the J. prefer-IND.IPFV.3SG meet(%3PL)-RECP more late
'João would prefer to meet later.'

In the exhaustive control example (47a) the inflection on the infinitive is not permitted just as with raising in (46c). In (47b) on the other hand the notation % implies significant percentage differences in the judgements of native speakers, a conclusion confirmed by the more detailed statistical evidence presented in Sheehan (2018a,b). In this respect they parallel the cross-speaker discrepancies noted with respect to clitic climbing in the Italian PC example (39b). Such a degree of socio-pragmatic variation in turn would seem to support Haug's concept of a control scale moving from pure syntax through to discourse rather than attempts to motivate the differences in terms of core syntactic concepts such as Case and Agree.

All the languages we have considered in this section so far share the property of having morphological realizations of finiteness and the related categories of tense, mood and person. Mandarin Chinese, and Sinitic languages more generally, however do not exhibit such morphology and therefore call into question to relevance of the finiteness criterion in a different way (see Grano 2015: chapter 6 for discussion and a convenient summary of the relevant literature). In his LFG-based discussion of this and related issues, Lam (2022) bases his analysis on the contrast between the f-structure for *shefa* 'try' with xcomp as opposed to comp for the partial control verb *dasuan* 'intend' and with an VP complement for the former beside an IP complement for the latter.

7 Backwards control/raising and subsumption

As we have seen, the treatment of control and raising constructions in LFG relies on f-structure statements of the form (↑ subj) = (↑ xcomp subj), which imply equality between the content of the functional roles but asymmetry in the dominance relations since the thematic argument will of necessity occur in the higher clause. This is the case even if the linear order differs, as in the Hungarian examples (40b) and (40d) where *akar* 'want' follows rather than precedes its infinitival complement. However, an example like (48) from the North Caucasian language Adyghe evidences a different pattern, in which the thematic argument can be situated in the embedded clause (Potsdam & Polinsky 2012: (1), (2)), where the strikethrough items indicate deletion in their notation):

(48) Adyghe

a. ~~axe-r~~ [axe-me se saš'e-new] ∅-feže-ʁ-ex
   3pl-abs 3pl-erg 1sg.abs lead-inf 3abs-begin-pst-3pl.abs

b.	axe-r	[~~axe-me~~ se		saš'e-new]	∅-feže-ʁ-ex
	3PL-ABS	3PL-ERG	1SG.ABS	lead-INF	3ABS-begin-PST-3PL.ABS

'They began to lead me.'

While (48b) has an overt absolutive subject of the verb *feže* 'begin', accompanied by an unrealized subject of the embedded infinitive *saš'enew* 'lead', in (48a) the overt item is *axe-me* with the ergative suffix appropriate for the subject of 'lead'.

The examples in (48) demonstrate a free alternation between forward and backward raising. At the same time, as Perlmutter (1970) demonstrated in a classic paper, verbs meaning 'begin' can vary between raising and control uses. An instance of backward control with 'begin' can be seen in the Malagasy example (49a). The difference here is both in the theta role — Rabe is the active beginner and the active driver — and in the fact that in Malagasy the forward version (49b) is ungrammatical.

(49) Malagasy

a.	m-an-omboka	[m-i-tondra	ny	fiara	Rabe]
	PRS-ACT-begin	PRS-ACT-drive	the	car	R.

'Rabe is beginning to drive the car.'

b.	*m-an-omboka	Rabe	[m-i-tondra	ny	fiara]
	PRS-ACT-begin	R.	PRS-ACT-drive	the	car

Here only the backward control option is possible, a property which Sells (2006) proposes can be modelled by introducing the subsumption relation, annotated as $\sqsubseteq$, which implies a directionality in the flow of information from controller to controllee but involves no expectation of hierarchy. The difference between the 'begin' verbs in Adyghe and Malagasy can then be represented as in (50):

(50)

a.	Adyghe:	*feže*	(↑ SUBJ) $\sqsubseteq$ (↑ XCOMP SUBJ)
			(↑ XCOMP SUBJ) $\sqsubseteq$ (↑ SUBJ)
b.	Malagasy:	*omboka*	(↑ XCOMP SUBJ) $\sqsubseteq$ (↑ SUBJ)

This kind of cross-linguistic difference is part of a larger typological distribution. Table 3, adapted from Polinsky & Potsdam (2002: 278), shows the various patterns which have been attested to date for verbs meaning 'begin', which fall within the larger class of verbs with an aspectual meaning, something which seems to be a key factor here.

The concept of subsumption and its relation to backward control and raising goes back to Zaenen & Kaplan (2002), who propose as a general principle that

Table 3: Typology of backward control with 'begin'

Language	Backward control	Aspectual	Raising/control ambiguity
Tsez (Nakh-Daghestanian)	yes	yes	yes
Malagasy (Austronesian)	yes	yes	no
Tsaxur (Nakh-Daghestanian)	yes	yes	no
English	no	yes	yes

raising verbs involve the equality relation (↑ SUBJ) = (↑ XCOMP SUBJ) while control/equi verbs have the subsumption relation (↑ SUBJ) ⊑ (↑ XCOMP SUBJ). Sells (2006) goes a step further and proposes to replace equality with subsumption across the board. The debate, however, has not been settled in part because, as we have seen, there are arguments in favour of control as involving COMP rather than XCOMP and in part because others, notably within LFG (Arka 2014), have argued that both mechanisms can be at work in the same language.

Polinsky & Potsdam (2006) and again Polinsky (2013) argue that backward raising/control supports a movement account, and in particular a copy-and-delete version, with the difference cross-linguistically depending on whether it is the original or the moved copy that is deleted, but as noted above this analysis faces problems when it comes to copy control constructions. At the same time, Polinsky (2013) raises two queries vis-à-vis Sells and subsumption: a) is there a risk of over-generation? and b) how does it connect with other properties such as word order and headedness?

On this last point, Haug (2011, 2017) extends the discussion of backward control to include adjunct clauses as in the Ancient Greek (51) (= example (15) from Haug 2011):

(51) Ancient Greek
[egertheis de Iôsêph apo tou hupnou]
wake.PFV.PTCP.NOM but Joseph.NOM from DEF.GEN dream.GEN
epoiêsen...
do.PST.PFV.3SG
'When he woke up from the dream, Joseph did...'

Here, the subject of the *epoiêsen* 'did' is realised in the adjunct participial clause, which linearly precedes but is structurally subordinate to the main clause. For this reason, as Haug notes, it might be better to refer to 'upward' control but either way we have something that is parallel to the kind of pattern we have seen in our earlier examples of backward complement control. However, as he goes on to show, the appropriate analysis here involves functional equivalence and linear precedence rather than subsumption, a conclusion which suggests that subsumption as an operation, if required at all, should be restricted to contexts of complement control and raising, where as examples like (48) and (49) demonstrate linearization cannot be the answer.

8 Nominal control and raising

Another logical possibility is that the controlling item is nominal rather than verbal. This is particularly evident in the structure which, following Tsunoda (2020), we will call the Mermaid Construction (MC), as seen in the Japanese examples (52) and (53):

(52) Japanese

Hanako=ga	Igirisu=ni	ik-u	ki=da
Hanako=NOM	UK=DAT	go-NPST.ADN	feeling=COP.NPST.DECL

'Hanako intends to go to the UK.' (lit 'Hanako is the feeling to go to the UK' or 'It is the feeling where Hanako goes to the UK')

(53) Japanese

Hanako=ga	Igirisu=ni	ik-u	yotei=da
Hanako=NOM	UK=DAT	go-NPST.ADN	plan=COP.NPST.DECL

'Hanako is going to the UK.' (lit 'Hanako is the plan that goes to the UK' or 'It is the plan where Hanako goes to the UK')

The mermaid label reflects the fact that these are mixed constructions involving a full noun, *ki* 'feeling' and *yotei* 'plan', and an associated clitic copula *da* 'be' which taken together govern a dependent nominalized verb *ik-* 'go' and which translate as modal or aspectual markers. Tsunoda (2020) analyses these examples as monoclausal with the sequences *iku kida* and *iku yotei* being treated as complex predicates. Taguchi (2022), however, argues that the structures in question are bi-clausal and hence allow independent negation and adverbials for both predicates:

(54) Japanese

Kinoo Hanako=ga [asita Igirisu=ni ik-u]
yesterday Hanako=NOM tomorrow UK=DAT go-NPST.ADN
yotei=datta
plan=COP.PST.DECL
'Yesterday Hanako planned to go to the UK tomorrow.'

(55) Japanese
Hanako=ga [Igirisu=ni ik-anai] yotei=dewanai
Hanako=NOM UK=DAT go-NEG.NPST.ADN plan=NEG.COP.PST.DECL
'Hanako did not plan not to go to the UK.'

He therefore proposes the following lexical entries, where *ki* involves anaphoric control while *yotei* is treated as a raising verb with functional control:

(56) a. *ki* N (↑ PRED) = 'KI⟨SUBJ,COMP⟩'
(↑ COMP SUBJ PRED) = 'PRO'

b. *yotei* N (↑ PRED) = 'YOTEI⟨XCOMP⟩SUBJ'
(↑ SUBJ) = (↑ XCOMP SUBJ)

Examples of the MC are found across a wide range of languages — twenty-six in Asia and one in Africa according to Tsunoda (2020: 1), to which Taguchi adds parallel examples from Scots Gaelic, Tatar and Russian. Here is not the place to compare these in detail and it may well be that, even if Taguchi is right and the monoclausal analysis does not hold for Japanese, this is the correct account for the construction in other languages. What more generally, therefore, this data demonstrates is the fuzzy border between raising/control constructions and complex predicates, and the likelihood that over time the former may develop into the latter (see Butt 2014, Booth & Butt forthcoming [this volume] and the discussion in Section 13 below).

9 Copy raising, control and resumption

In addition to the widely discussed examples with an infinitival complement, the English verb *seem* also allows the pattern to be seen in (57) in which the subject of *be sick* appears to have been raised and replaced by the pronoun *he* in the complement clause.

(57) Alfred sees like/as if he's sick.

Structures of this kind have been labelled 'copy raising' with the pronoun being treated as 'resumptive' (Asudeh & Toivonen 2007, 2012; Asudeh 2012). The last-mentioned work in particular shows how this construction can be naturally accounted for by invoking resource logic and glue semantics, as well as demonstrating the cross-linguistic evidence for similar structures. As Asudeh (2012: chapter 12) shows, the availability of copy raising is lexically determined; it is attested with *seem* and *appear* but not for example with *tend*:

(58) *Alfred tends like he won.

The items in question will therefore have a lexical specification via a local copy name as in (59) together with the usual open function to link the main clause subject and the subject of the embedded predicate *like*:

(59) *seem* V ($\uparrow$ SUBJ)$_\sigma$=(%COPY$_\sigma$ ANTECEDENT)
($\uparrow$ SUBJ) = ($\uparrow$ XCOMP SUBJ)

(60) *like* P ($\uparrow$ PRED) = 'LIKE⟨COMP⟩'

The f-structure for *like* needs to include the COMP function in order to cope with the fact that the clause following like is finite. What has been more open to contention is its categorial status, with some arguing for it as a complementizer but with Asudeh opting for the more traditional assumption that it is a preposition. The latter is more plausible given that it can also take a simple NP as in *Alfred looks like his sister*. This solution would also allow for a transparent analysis of the *as if* alternant in (55) with *as* being a P parallel to *like* and with *if* as the C head of the embedded COMP.[5] The prepositional account finds support in the analysis advanced by Camilleri (2018), also within the framework of LFG, of the parallel constructions in Maltese, as in (61) (= her example (32)):

(61) Maltese

qis-ha	bħal(likieku)	ta-w-ha	xebgħa
as.though-3F.SG.ACC	as.if	give.3PFV-PL-3F.SG.ACC	smacking

'She's as though they gave her a smacking.'

We see here a copy raising construction with a null copula (compare the Maltese data in (7) above) and where the optional element *likieku* is indeed a counterfactual complementizer but crucially can only occur in this construction as the complement of the preposition *bħal* 'like'.

[5] Gisborne (2010: chapter 7) also argues for treating *like* as a preposition albeit in the context of a different Word Grammar analysis of the construction as a whole. Landau (2011) by contrast opts for a derivation-based account in which like is treated as a complementizer.

Although space here has only allowed us to look at some core examples of this construction, this has sufficed to demonstrate the importance of such data for the analysis of the relation between semantics, syntax and lexis. Further issues concern the relation between these examples and the ones in (62):

(62) a. Alfred seems like Thora hurt him.
b. Alfred seems like Thora's hurt.
c. Alfred sounds/looks like he enjoyed the party.

In (62a) the co-referential argument is an object not a subject and in (62b) there is no overt co-referent but simply a context-derivable assumption that Alfred and Thora are somehow connected. Such an assumption makes clear the route by which the speaker has reached their conclusion, hence the label 'perceptual resemblance verb' (PRV) that has been applied to such items. (Compare too in this connection example (67b) in Section 12 below.) While Asudeh (2012: 351–356) demonstrates how examples like (62) and the dialect variation associated with them can be captured, Toivonen (2021) is an exploration of PRVs and the way they vary between English and Swedish.

This construction with raising verbs has its counterpart in the domain of control verbs as we saw in connection with the so-called 'copy control' construction exemplified in (44), where it is the thematic controller which recurs as a pronoun in the embedded finite clause.

10 The semantics of raising and control

While much of the literature both within and outside LFG seeks to account for control and raising effects in syntactic (i.e. f-structure and/or c-structure) terms, there is an important strand of work which argues that the phenomenon is at heart semantic (for English see Jackendoff & Culicover 2003, Culicover & Jackendoff 2006 and references there, Duffley 2014, and compare Akuzawa & Kubota 2020 for Japanese). In the words of Culicover & Jackendoff (2006: 152): 'Control should be taken out of the hands of the syntax and turned over to the semantics.'

In fact, these debates can be broken down into two separate, though not unconnected, issues. The first concerns the semantics of the governing predicates, which can be divided into a series of lexical sub-classes defined in terms of their semantic content of their predicates and hence their associated thematic roles. Thus, for example, in their treatment of control in Japanese, Akuzawa & Kubota (2020) distinguish the following classes:

(63) Attitudinal, e.g. *try*, *decide*
Commissive, e.g. *declare*
Directive, e.g. *order*
Implicative, e.g. *succeed*
Factive, e.g. *regret*

Such a list is clearly not exhaustive but it goes a good way towards predicting the types of structures and arguments that will be found with the items in the different classes. It is very much in line with the Culicover & Jackendoff way of thinking and with the recent work by Landau discussed below. That said, the fact remains that raising and control exhibit overt syntactic patterns that need to be accounted for. It is striking that the model deployed by Culicover & Jackendoff under the name 'Simpler Syntax' makes crucial use of grammatical relations (GR in their notation) rather than categorial structure in a way that is strikingly similar to the role of f-structure. By contrast a model like Role and Reference Grammar treats raising and control directly in terms of thematic roles without intervening recourse to grammatical functions (see Bentley & Vincent forthcoming [this volume]). Within LFG, the role of meaning, and more precisely the relation between a-structure and f-structure, is handled by lexical mapping theory — see the chapter by Findlay & Kibort forthcoming [this volume] — and semantically defined templates (Dalrymple et al. 2019: 230–237).

A separate issue concerns the semantic category to be assigned to the complement: is it to be treated as a proposition, as in Dalrymple (2001) or a predicate, as suggested by Asudeh (2005)? The proposition/predicate debate is one which arises in other frameworks. Thus, Pearson (2016) argues for the property interpretation contra Landau and the use of the contrast in relation to adjunct control in Landau (2021). We return to this issue in Section 11 and Section 12.

11 Predication vs logophoric anchoring

In a substantial contribution to the debate Landau (2015) proposes what he calls a 'two-tiered' theory of control, more precisely a binary division of OC; NOC remains outside this picture. On the one hand, there is logophoric anchoring where the controlling predicate is labelled 'attitudinal'.[6] This contrasts with predicative

[6]The concept of logophoricity goes back to Hagège (1974) with specific reference to languages which distinguish between two sets of pronouns according to whether the antecedent is the speaker or not. Sells (1987) offers an early formalization in terms of Kamp's discourse representation structures. Landau's use of the term is rather more general but shares the key idea of reference back to the speaker.

anchoring, which applies to non-attitudinal verbs. The two classes can be further divided into sub-classes:

(64) a. attitudinal: desiderative, propositional, interrogative, factive, e.g. *want, refuse, agree, ask, pretend, plan, imagine*, etc.

b. non-attitudinal: modal, aspectual, evaluative, implicative, e.g. *dare, see, remember*, etc.

Building on this distinction Landau (2015: 20) states the following generalization:

(65) Nonattitude complements force EC, attitude complements allow PC.

This in turn is worked out in terms of a semantic distinction between what he calls a 'property-denoting projection', which defines predicative control, and a 'propositional projection', which defines logophoric control. Propositional projections involve an extra layer of syntactic structure above the layer containing the property projection and hence they are 'two-tiered'. He sets out the properties of the two types of control in Table 4, and he sums up the resulting empirical contrasts between the two in Table 5.

Table 4: Properties of control constructions (Landau 2015: 83)

	Predicative control	Logophoric control
Semantic type of complement	$<d,<e, <s,t>>>$	$<<e,<\kappa,e>>,<\kappa,t>>$
Head of complement	transitive $\text{Fin}_{[uD]}$	transitive $\text{C}_{[uD]}$
Control and agreement are established via:	predication	predication + variable binding

Table 5: Empirical diagnostics of control constructions (Landau 2015: 65)

	Predicative control	Logophoric control
Inflected complement	✓	*
[– Human] PRO	✓	*
Implicit control	*	✓
Control shift	*	✓
Partial control	*	✓
Split control	*	✓

The diagram from Landau (2015: 85) reproduced in Figure 1 shows his conception of the relations between the two types of control. Two questions then arise:

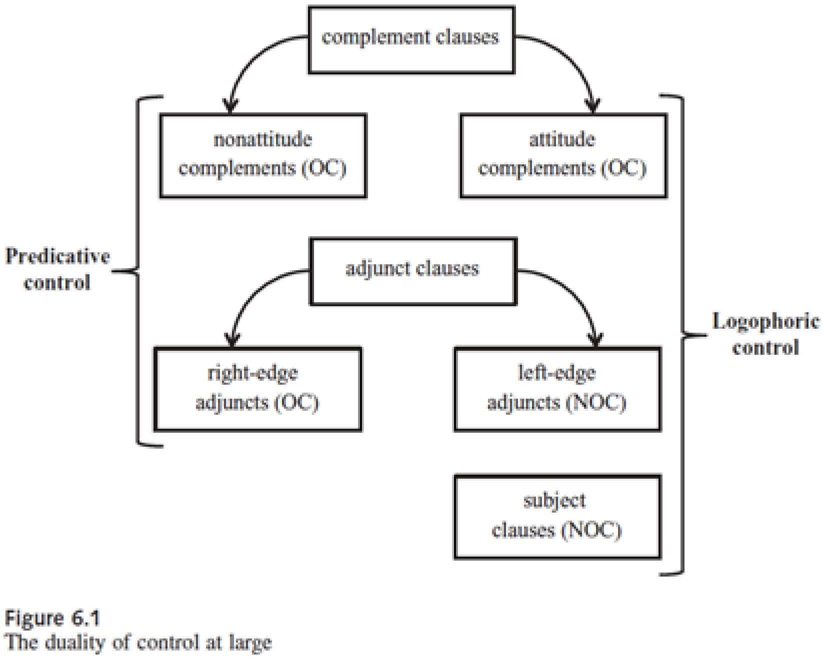

Figure 1: Landau's (2015) two types of control MD: redo this diagram?

do we need this distinction? And if not, how can the issues it is designed to address be accommodated within a framework like LFG? The answer to the first question is probably not and to the second, they already have been! Thus, as we have noted, Reed (2020) discusses objections to the two-tier account contrasting it with a single-tier approach and citing in this connection Haug (2014). She goes on to develop her own category-based syntactic account but once again we see that elaborating syntactic configurations is an alternative, and less economical, analytical strategy compared to the functional definitions that lie at the heart of LFG, especially once they are combined with a semantics of the Glue type.

12 Adjunct control

In the standard literature, adjunct control, as exemplified in (5) — repeated here in (66) for convenience — has received relatively little attention by comparison with other types of control:

(66) a. Glad to be home again, Sally waved to her neighbours in the garden.
b. Bill called a plumber to fix the drain.
c. Sally came across Bill in the garden crying his eyes out.

Recently, however, there have been some significant contributions which provide interesting contrasts in the way the phenomenon can be modelled. Thus, Green (2019) extends the movement account and challenges an early version of the approach now developed in Landau (2021), where he builds on the two-tier model discussed in the previous section. The LFG account developed in Donaldson (2021a) adopts a similar line of argument, but this is revised in Donaldson (2021b).

Consider the pair of examples cited at the beginning of Donaldson (2021b):

(67) a. Watching him, Thrasher realized that something in his appearance didn't ring true. (Green 1956: *The Last Angry Man*)
b. Watching him, it seemed as if a fibre, very thin but pure, of the enormous energy of the world had been thrust into his frail and diminutive body. (Woolf 1942: *The Death of the Moth*)

In (67a) the missing subject of *watching him* is supplied by the subject of the main clause. By contrast, *his* in *his appearance* is interpreted pragmatically as referring to the same individual as referenced by *him*. If *appearance* was replaced by *memory*, the natural antecedent of *his* would be *Thrasher*. Similarly, it is the context in (67b) which leads the reader to link *him* and *his body*. However, it is also the context that determines the missing subject of *watching him* since there is no argument in the main clause which can fill that role. In short, there is no debate over the fact that structures like (67b) require an extrasentential interpretation of the missing argument, in other words arbitrary anaphoric control and hence in the rightmost box of Haug's Table 1 above.

When it comes to examples like (67a), however, different accounts have been proposed. Donaldson (2021a) follows a line of analysis within LFG going back to Mohanan (1983) and argues that the strict link in interpretation between the missing argument and the subject of the main clause is best treated as an instance of functional control providing the link to the open XADJ clause. However, Donaldson (2021b) notes that a functional control analysis will not generalise to examples like (68) where there is an embedded gerund, but nonetheless the two types of structure pattern similarly in other respects as can be seen in (69).

(68) After a year of complaining, Bill finally left his job.

(69) a. After three days of preparing himself/*herself, Bill spoke to Sue.
b. While preparing himself/*herself, Bill helped Sue.

He therefore proposes an obligatory anaphoric control analysis for both. How then do we distinguish between obligatory and arbitrary anaphoric control in adjuncts?

Adjunct control cross-cuts the opposition between OC and NOC, leading Landau (2021: 21) to propose the following criteria:

(70) a. Locality: an OC controller must be an argument of the clause immediately dominating the adjunct.
b. Humanness: PRO in NOC, but not in OC, must be [+ human]

A different issue concerns the location of the adjunct clause. As is clear from the diagram above, Landau consider his two-tier theory to apply to both and draws a distinction between right edge adjuncts, which involve OC and are predicative, and left edge adjuncts, which involve NOC and are logophoric (compare already Williams 1992 on logophoricity and adjunct control). Hence by the principle in (70b) left edge adjuncts will be interpreted as holding of a human argument. This conclusion appears to be supported by the examples in (71) cited by Donaldson (2021b):

(71) a. Being made of stainless steel, rust won't be an issue. (after Davies 2018)
b. *Rust won't be an issue, being made of stainless steel.
c. The knife resists rusting, being made of stainless steel.

(71a) is acceptable even though the extrasentential controller is necessarily inanimate, while (71b) fails because the adjunct is now left edge and therefore is required to be human unless it can be interpreted as an instance of OC as in (71c).

An alternative account of the difference between OC and NOC adjuncts is advanced by Fischer & Høyem (In preparation, 2022). Instead of a reference to right and left they distinguish the levels of emebedding and hence syntactic scope as the determining factor. OC is limited to arguments within the verbal domain, while proposition modifying adjuncts, which display NOC properties, are interpreted on the basis of pragmatic factors. The common property of all of these accounts is that they involve a scale moving from syntax (whether relationally or categorially defined) through semantics to pragmatics, a scale which we have now seen more than once is best defined in the terms of Haug (2013, 2014) rather than always being reduced to a syntactic configuration. An interesting additional dimension introduced by Donaldson is that of processing, who adduces the psycholinguistically based principle that, in his words, 'language users guess at a controller as soon as it becomes apparent that one is required' (Donaldson 2021b: 100), and hence with differential consequences for initial, medial and final adjuncts. There are also parallels here with the linearization effects noted by Haug (2017) in connection with examples like (51) above.

13 The diachrony of raising and control

Most of the literature on raising and control constructions is synchronic in orientation but there has been some work on the way these patterns may change over time. In this section we will briefly consider some case studies and the contribution made by an LFG-based approach to modelling them.

Our first examples come from the work of Barron (1997, 2001) on the historical development of 'seem' verbs from verbs of perception. One such is Latin *videri*, formally the passive of the verb *videre* 'see' but commonly used in the sense of 'seem' as in (72) contrasted with its literal meaning in (73):

(72) Latin

… ill-orum	beata	mors	vid-et-ur
they-GEN.PL	blessed.NOM.F.SG	death.NOM.F.SG	see-PRS.3SG-PASS

'… their death seems blessed' (Cicero De amicitia 23,7)

(73) Latin

ubi	sol	etiam	sex	mensibus	continuis	non	vid-et-ur
where	sun.NOM.SG	even	six	month.ABL.PL	continual.ABL.PL	NEG	see-PRS.3SG-PASS

'where the sun is not seen for six months in a row' (Varro *Res rusticae* 1,2,4)

What (72) and (73) share is that the perceiver argument has been suppressed and in consequence the object of perception comes to fill the SUBJ function in virtue of the Subject Condition. However, the verb's inflectional morphology and the syntactic configuration of the clause remain unchanged. In Latin both uses are attested over a long time span, but following the general principle of grammaticalization that concrete meanings develop into abstract ones rather than vice versa, it is reasonable to suppose that the 'be seen' meaning is older than the 'seem' meaning.

The diachronic sequence is not in doubt in Barron's second example, namely the development of French *sembler* and Italian *sembrare*, both meaning only 'seem', from the Latin *simulare* 'pretend'. At the level of function and argument structure the change is parallel. In this case, the 'pretender', that is to say the causer of the perception has been lost with the result that the object that has been made to appear takes over the subject role.

While the above examples involve the historical shift into a raising function of items that were already etymologically verbs, our next examples, drawn from Camilleri & Sadler (2019), show how the same verbal function may develop from items that belong to other categories, specifically here a noun *šakl* 'shape, form' and a preposition *zēy* 'like'. Example (74) shows the 'shape' word in its nominal use together with a dependent genitive and a predicative adjective that can agree either with the masculine head *šakl* or its possessive feminine dependent *dærah* 'circle'. (Note here that there is no copula since this is present tense, as with the Maltese example (7a) above.)

(74) Maltese

šakl	id-dærah	mdawwar/mdawwar-ah
shape.M.SG	DEF-circle.F.SG	round.M.SG/round.F.SG

'The shape of the circle is round.' (Egyptian)

In (77) by contrast *šakl* serves as a raising predicate taking the perfective *rigiʕ* 'return' as its complement:

(75) Maltese

Morsi	šakl-u	rigi-ʕ
M.	shape-3M.SG.GEN	return.PFV.3M.SG

'Morsi seems to have come back.' (Egyptian)

In LFG terms the diachronic development here involves a shift from the predicate 'ŠAKL⟨POSS⟩' to 'ŠAKL⟨XCOMP⟩SUBJ'.

Camilleri & Sadler's (2019) second case can be seen in the difference between the examples (76) and (77) from two different varieties of Algerian Arabic drawn from studies conducted at different time periods:

(76) Saïda Algerian Arabic, 1908

lābes	zēy	el-myāṛba
wear.ACT.PTCP.M.SG	like	DEF-moroccan.PL

'He was wearing (i.e. dressed) like Moroccans.'

(77) Djidjelli Algerian Arabic, 1954
zēyu nsā-na
like.M.SG.GEN forget.PFV.3M.SG-1PL.ACC
'He seems to have forgotten us.'

In this instance the source is prepositional but the outcome once again is a raising predicate: 'ZĒY⟨XCOMP⟩SUBJ'. Semantic parallels for this development are to be seen in the use of English like in the copy-raising constructions reviewed in Section 9 and in the origin of Latin *simulare* 'pretend' discussed above as a causative built on the same stem as *similis* 'similar'.

What all these examples taken together demonstrate is that it not the categorial status of the etymon — verb, noun, adposition respectively — that unites them but a common semantic core plus a the transition to the functional structure ⟨XCOMP⟩SUBJ, a shared development that a framework like LFG is ideally equipped to model.

We move now to the development of a control predicate, namely WILL verbs in Germanic. These can all be traced back to the Proto-Indo-European root **wel-* , and are cognate with Latin *velle* 'want' which in turn is the source of French *vouloir* and Italian *volere* discussed in Section 6. As Börjars & Vincent (2019) show in detail, comparing items across the family reveals a sequential development from the original 'want' meaning through to the future and intentional meanings of modern English. The most conservative languages are Swedish and Icelandic where in the modern languages the verb *vilja* has only 'want' meanings and in that respect resembles the Danish pattern set out in (36) above. Modern English *will*, by contrast, has lost these uses though they are attested in Old and Middle English. Danish stands in between in the sense that it has retained the 'want' meanings but has also developed the intention and future meanings. Hence an example like (78) is ambiguous:

(78) Danish
Peter vil hjælpe dig
P. will.PRS help.INF you.ACC
'Peter will help you.' OR 'Peter wants to help you.'

Within grammaticalization studies developments of this kind are typically modelled in terms of informal scales or semantic maps (Bybee et al. 1994, Narrog & van der Auwera 2011) such as the one proposed in Börjars & Vincent (2019: 301):

(79) DESIRE → INTENTION → PREDICTION

We can now offer a more refined version of this development; in effect a diachronic instantiation of Haug's scale:

(80) QUASI-OBLIGATORY AC → AC → FC → PREDLINK

What we see here, then, is the development from an independent lexical item to control verb to raising verb and ultimately to simple of marker of tense and/ or aspect, as is consistent with the cross-linguistic diversity in the etymology of control and raising verbs (Barron 2001, Vincent 2019). One may compare too the diachronic development from control verb to complex predicate discussed in Butt (2014) and in Booth & Butt forthcoming [this volume].

14 Conclusion

The general conclusion that emerges from this chapter, in line with the view expressed by Landau (2013: 257–258), is that control and raising do not constitute a unitary phenomenon. Rather such pre-theoretical labels subsume a variety of structural possibilities that vary across languages and which may change over time. However, contrary to Landau (2013, 2015), we argue that these patterns not only can be captured within a framework like LFG but also that a parallel correspondence model of this kind, which does not make all generalizations hinge on syntactic configurationality, has the potential to offer richer insights in both the synchronic and diachronic domains.

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Abbreviations

Besides the abbreviations from the Leipzig Glossing Conventions, this chapter uses the following abbreviations.

ACT	active	HAB	habitual
ADN	adnominalizer	INFL	head of IP
C	complementizer	POT	potential
EXH	exhortative	PRT	particle

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Chapter 6

Glue semantics

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Glue Semantics is a general framework for semantic composition and the syntax–semantics interface. It assumes an autonomous syntax and therefore needs to be paired with some syntactic theory. Here the focus is on LFG as the syntactic theory. The Glue logic, a fragment of linear logic, is presented first. This highlights the resource sensitivity of semantic composition in Glue. Second, Glue is presented without reference to LFG or any other syntactic theory. This highlights Glue's property of flexible composition. Third, the syntax–semantics interface is considered. This highlights Glue's autonomy of syntax and serves as a way to compare and constrast Glue with well-known alternatives. Fourth, Glue is paired with LFG (LFG+Glue), which highlights another important property of the theory, syntax/semantics non-isomorphism. Lastly, a number of particular phenomena are briefly reviewed and their analyses sketched: quantifier scope, modification, tense, events, argument structure, multiword expressions, and anaphora.

1 Introduction

The fundamental principle of compositional semantics is the following:

(1) *Principle of Compositionality (PoC)*
The meaning of a whole is a function of the meanings of the parts.
(Partee 1995)

According to the PoC, the meaning of an expression depends on its parts, but also on its syntax. The aspects of syntax that are relevant are standard features like NUMBER, PERSON, TENSE, etc., as well as syntactic predicate-argument relations and local and non-local syntactic dependencies. These are all represented

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in f(unctional)-structure in LFG, so the relevant syntactic representation for compositional semantics in LFG is f-structure.

But how are compositionally relevant features and relations obtained from f-structure? This is really a question about the mapping between syntax and semantics, or the nature of the *syntax–semantics interface*.[1] There are two fundamental ways in which different levels in LFG's Correspondence Architecture (Kaplan 1987, 1995) can be related: *description by analysis* and *co-description*. Both methods have been applied to the syntax–semantics interface in LFG.

Halvorsen (1983) developed the initial semantics for LFG, in which an f-structure is analyzed for features, including grammatical functions and other relational dependencies, to obtain a description of the compositional semantics. This is an example of *description by analysis* (Halvorsen & Kaplan 1988, Kaplan 1995) and is similar in spirit to Logical Form (LF) semantics (Heim & Kratzer 1998), even though the input syntactic structures are formally quite different. The description-by-analysis approach to LFG semantics effectively makes the same assumption as LF semantics: the semantic interpretation function applies to an entire syntactic structure — a standard non-tangled tree in LF semantics or an f-structure in description-by-analyses semantics for LFG.

Halvorsen & Kaplan (1988) offered a co-description alternative. According to co-description, a lexical item specifies its c-structural category, which captures its syntactic distribution, and also simultaneously specifies its contributions to f-structure, s(emantic)-structure, and any other grammatical modules. The contribution to f-structure, s-structure, etc., is accomplished though a set of constraints and equalities whose solutions determine the lexical item's non-c-structural contributions.[2] Thus, a syntactic formative on this view simultaneously *co-describes* its contributions to compositional semantics.

Glue Semantics (Glue) further develops and logically systematizes the co-description idea of Halvorsen & Kaplan.[3] In contrast to description by analysis, co-descriptive LFG semantics is in the spirit of the syntax–semantics interface tradition that developed out of the *rule-by-rule* approach of Montague (1973), to

[1]Unfortunately, this term has been somewhat bleached of meaning through overuse in syntactic theory, where the mapping is often not specified in sufficient detail.

[2]See Asudeh (2012: ch. 3) for a basic introduction to one version of the Correspondence Architecture.

[3]The implementation of Glue that was developed for the Xerox Linguistic Environment (XLE) implementation of LFG (Crouch et al. 2011) used description-by-analysis, but out of necessity rather than by design. The co-descriptive version of Glue would have required changes to the underlying XLE implementation, whereas description-by-analysis Glue did not. Also see Andrews (2008) for a consideration of description-by-analysis versus co-description approaches to Glue.

use the terminology of Bach (1976). This tradition is standardly exemplified by Categorial Grammar (CG; for a basic overview and foundational references, see Wood 1993). In fact, Dalrymple, Gupta, et al. (1999) discuss how Glue is strongly related to Categorial Grammar in the type-logical tradition (for overviews and further references, see e.g., Carpenter 1997, Morrill 1994, Morrill 2011, Moortgat 1997).

However, Glue Semantics and Categorial Grammar make distinct assumptions about the relation between the syntax of word order and the syntax of compositional semantics (for discussion and further references on this aspect of CG, see Steedman 2014). LFG's claims about Universal Grammar (Bresnan et al. 2016: ch. 4) serve to highlight the distinction. C-structure, which represents word order, is highly variable cross-linguistically, whereas f-structure, which represents syntactic features and dependencies, is largely invariant cross-linguistically. This is reflected in the fact that although embedding is significant at f-structure, order among features in the same f-structure is not:

(2) $\begin{bmatrix}\textsc{att1} & \begin{bmatrix}\textsc{att2} & \textsc{val}\end{bmatrix}\end{bmatrix}$

$\neq \begin{bmatrix}\textsc{att2} & \textsc{val}\end{bmatrix}$

(3) $\begin{bmatrix}\textsc{att1} & \textsc{val1}\\ \textsc{att2} & \textsc{val2}\end{bmatrix}$

$= \begin{bmatrix}\textsc{att2} & \textsc{val2}\\ \textsc{att1} & \textsc{val1}\end{bmatrix}$

A language with relatively free word order (e.g., Warlpiri) has quite different c-structures from a language with relatively fixed word order (e.g., English). However, the two languages have similar f-structures, which predicts that they are similar with respect to syntactic features and dependencies (Bresnan et al. 2016: ch. 1). It would be antithetical to the theory for compositional semantics to be computed from c-structure, since the cross-linguistically relevant information for semantics is captured in the unordered f-structure. So Glue Semantics uses a commutative logic for composition, which turns out to yield insights beyond those which originally motivated Glue.[4] This will be explored more carefully below, from a higher level perspective.

The first papers in the Glue Semantics (Glue) framework were published in the mid-nineties (Dalrymple et al. 1993, Dalrymple, Lamping, Pereira, et al. 1995, Dalrymple, Gupta, et al. 1997, Dalrymple, Lamping, Pereira, et al. 1997). The initial

[4]Note that the term *logic* here is intended not merely in the sense of a representational language for meaning, but rather a deductive system for deriving formulae from other formulae, i.e., proving conclusions from premises and previously proven conclusions.

major publications on Glue, including revised versions of most of these papers, appeared in Dalrymple (1999). These publications all assumed some version of LFG syntax. It should be borne in mind, however, that Glue Semantics (Glue) is a general framework for semantic composition and the syntax–semantics interface and is in that sense independent from LFG per se. The key syntactic assumption that Glue makes is headedness, which is universal across formal syntactic theories, even if specifics vary. Glue thus offers a highly flexible and adaptable approach to semantic composition and the syntax–semantics interface. In addition to LFG, Glue Semantics has been defined for a number of syntactic frameworks, including Lexicalized Tree-Adjoining Grammar (Frank & van Genabith 2001), HPSG (Asudeh & Crouch 2002b), Minimalism (Gotham 2018), and Universal Dependencies (Gotham & Haug 2018).

Asudeh (2022: 324) highlights the following high-level properties of Glue Semantics:[5]

1. *Resource-sensitive composition*
   The logic of composition in Glue is *resource-sensitive*: The underlying logic of composition itself requires that all and only the resources/premises instantiated from the syntax are used in semantic composition.

2. *Flexible composition*
   The logic of composition in Glue is *commutative*. Semantic composition is systematically related to and constrained by syntax, but is not determined by syntactic word order. Semantic composition is tightly restricted by resource-sensitive composition.

3. *Autonomy of syntax*
   The logical assumptions of Glue yield a truly autonomous syntax, as a corollary of flexible composition. Semantic composition is commutative, but syntax is not: Syntax is subject to word order constraints that do not apply to semantic composition.

4. *Syntax/semantics non-isomorphism*
   Grammatical formatives, e.g. lexical items, may contribute multiple Glue terms that are all contributed to the semantic proof or no Glue terms at all, as a corollary of autonomy of syntax. There is no requirement that a formative must make exactly one contribution to interpretation.

[5]My thanks to an anonymous reviewer of Asudeh (2022) for suggesting the term *syntax/semantics non-isomorphism*.

In Asudeh (2022), I used these properties as organizing themes for a big-picture discussion that mostly backgrounded the combination of LFG in particular with Glue (often called LFG+Glue). Here I wish to instead foreground LFG+Glue, but it is nevertheless useful to have these properties in one place, as they will occasionally be referred to below.

I also want to emphasize that these properties are not fully independent, at least as given. The degree of resource sensitivity flows from the particular fragment of *linear logic* (Girard 1987) that one chooses for the Glue logic, but the implicative fragment with universal instantiation is commonly used and this fragment is highly resource sensitive, as explained in the next section. From resource sensitivity flow some automatic constraints on flexible composition such that it's not just 'anything goes.' Flexible composition in turn permits true autonomy of syntax, which fits naturally within LFG's general ethos of allowing mismatches between distinct linguistic modules in the Correspondence Architecture (Kaplan 1987, 1995, Asudeh 2006). Lastly, since syntax is autonomous from semantics, given flexible composition, it does not follow that a compositional analysis is only possible if each formative contributes exactly one meaning to semantic composition. Formatives may contribute nothing to meaning, e.g. expletive subjects or *do*-support *do*, or contribute multiple meanings to semantic composition.

2 The Glue logic: Resource-sensitive composition

The Glue logic is a fragment of *linear logic* (Girard 1987, Crouch & van Genabith 2000). Linear logic can be thought of as a logic of resources: Each premise in a linear logic proof must be used exactly once.[6] This can be usefully understood from the perspective of *substructural logics*. Substructural logics "focus on the behaviour and presence — or more suggestively, the *absence* — of *structural rules*. These are particular rules in a logic which govern the behaviour of collections of information." (Restall 2000: 1–2; emphasis in original). The basic intuition is that the choice of structural rules allows a precise logical characterization of some

[6] Girard (1987) defines two modal operators for linear logic, ! (*Of course!*) and ? (*Why not?*). These operators prefix particular premises (e.g., !A or ?A). This allows resource accounting to be turned off for the premise. Some early work in Glue used the ! modal in the analysis of coordination (Kehler et al. 1995, 1999). However, Asudeh (2004, 2005a) argued for a stricter notion of resource sensitivity that results from a simpler modality-free fragment of linear logic. Asudeh & Crouch (2002a) present a polymorphic Glue analysis of coordination (Steedman 1985, Emms 1990, 1992). The Asudeh & Crouch approach does not require the modality; also see Dalrymple et al. (2019: ch. 16).

system of information. Language can be construed as information. For example, Chomsky (1986, 1995) can be understood as characterizing language as information from a cognitive perspective. Another example is the characterization of language as information from a logical perspective, as in van Benthem (1991).

Three structural rules that are particularly relevant to substructural logics for linguistics are *weakening*, *contraction*, and *commutativity*:[7]

(4) *Weakening* Intuition: A premise can be *freely added*

$$\frac{\Gamma \vdash B}{\Gamma, A \vdash B}$$

(5) *Contraction* Intuition: Any additional occurrence of a premise can be *freely discarded*

$$\frac{\Gamma, A, A \vdash B}{\Gamma, A \vdash B}$$

(6) *Commutativity* Intuition: Premises can be *freely reordered*

$$\frac{\Gamma, A, B \vdash C}{\Gamma, B, A \vdash C}$$

If a logic *lacks* the rules of weakening and contraction, then premises in the logic cannot be added or discarded and the logic is therefore a *resource logic*.

However, we can also distinguish logics based on commutativity: A resource logic can be commutative or non-commutative. Linear logic is a commutative resource logic. In contrast, the Lambek logic L (Lambek 1958) is a non-commutative resource logic. L is the fundamental logic of the Lambek calculus, the basis for the type-logical approach to Categorial Grammar (see, e.g., van Benthem 1991, Moortgat 1997). The diagram in Figure 1 shows linear logic in a space of related substructural logics.[8]

The appropriate resource logic for semantics alone is a commutative resource logic. Semantic composition is resource-sensitive but does not show evidence of order-sensitivity in its own right (Asudeh 2012: ch. 5). Consider the general case

[7]The notation in these structural rules is understood as follows. Γ denotes a set of terms in the logic, whereas A, B denote particular terms in the logic. The single turnstile denotes a valid derivation/proof from the lefthand side to the righthand side; e.g., $\Gamma \vdash B$ means that B can be proven from Γ. The horizontal line separating the top and bottom of the rule means that the bottom can be derived from the top by the rule in question (i.e., the top *sequent*, can be replaced by the bottom one). For example, the weakening rule states that, given $\Gamma \vdash B$, one can conclude $\Gamma, A \vdash B$; i.e., every instance of $\Gamma \vdash B$ can be replaced by $\Gamma, A \vdash B$, given the rule.

[8]Note that the relation between intuitionistic logic and classical logic is characterized by the addition of the law of the excluded middle. However, this law is not strictly a structural rule, hence the dashed rather than solid line in the figure.

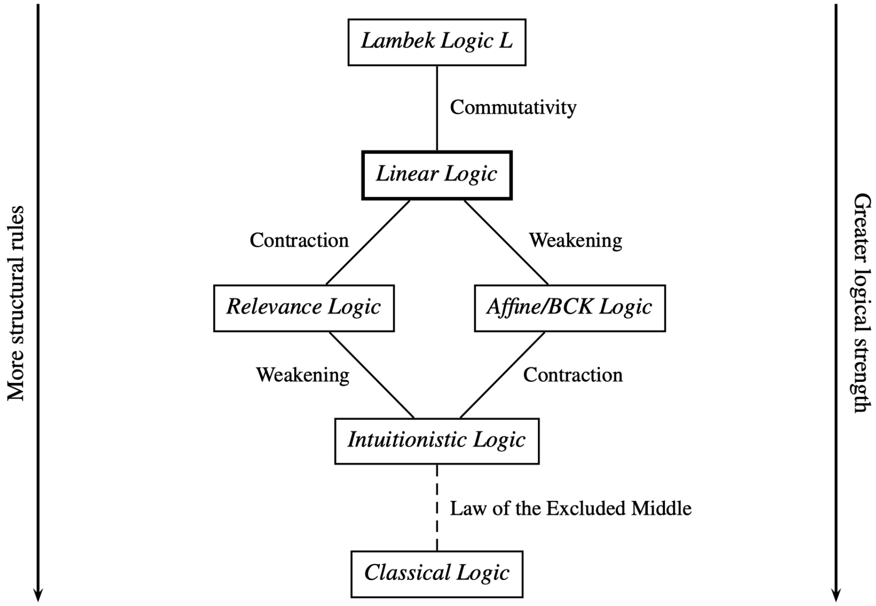


Figure 1: Hierarchy of logics related by structural rules (Asudeh 2012: 103; used with permission)

of some binary structure that is to be interpreted. If one branch denotes a function and the other denotes an argument, the function applies to the argument, whether the function is on the left or right:

(7)
$$\left[\!\!\left[\text{\textbf{function}} \quad \text{\textbf{argument}} \right]\!\!\right] = \left[\!\!\left[\text{\textbf{argument}} \quad \text{\textbf{function}} \right]\!\!\right]$$

For example, in English basic word order, the function that is the denotation of a transitive verb takes its argument to the right, but the resulting function that is the denotation of the VP takes its argument to the left.

It is not the *order* of the function and argument that determines their composition, but rather their semantic types (Klein & Sag 1985). This is saliently exemplified by the rule of functional application in the widely familiar system of Heim & Kratzer (1998: 44, 95). It is also exemplified by the equivalent interpretations of the forward and backward slash rules of Combinatory Categorial Grammar (see, e.g., Steedman 1987: 406 or Steedman & Baldridge 2011: 186).

But how is semantics resource-sensitive? The following quote from Klein & Sag (1985: 172) illustrates:

> Translation rules in Montague semantics have the property that the translation of each component of a complex expression occurs exactly once in the translation of the whole. … That is to say, we do not want the set S [of semantic interpretations of a phrase] to contain all meaningful expressions of IL [Intensional Logic] which can be built up from the elements of S, but only those which use each element exactly once.

In other words, Montague's translation rules are resource-sensitive. However, this is merely coincidental as far as his translation process is concerned. In their generalization of Montague's system, Klein & Sag (1985: 174) need to define an operation of *bounded closure*. This operation ensures that the meaning of each element of semantic composition is indeed used "exactly once."

We can obtain this result in a more general way, if we adopt a resource logic for semantic composition. This rests on the absence of the structural rules of contraction and weakening. The lack of contraction means that the number of occurrences of a premise matters, so a set of linear logic premises is a *multiset* (sometimes called a *bag*). The lack of weakening means that the bag must be emptied in constructing a valid proof. In other words, it follows directly from the absence of contraction and weakening that "each element" must be used "exactly once". Klein & Sag's bounded closure is effectively an attempt to capture the logical resource sensitivity of linear logic or L (Asudeh 2012: 110–111).

Logical resource sensitivity in turn forms the basis for linguistic resource sensitivity (Asudeh 2012: ch. 4). This is achieved by placing a linguistically motivated goal condition on the Glue logic proof; for example, we can require that the proof of a sentence terminates in a single meaning constructor of type t (Dalrymple, Gupta, et al. 1999). Asudeh (2012: 110–123) argues that resource-sensitive composition not only directly captures bounded closure, it arguably also captures a diverse set of principles across a variety of frameworks. These include Completeness and Coherence (Kaplan & Bresnan 1982), the Theta Criterion (Chomsky 1981), the Projection Principle (Chomsky 1981, 1982, 1986), No Vacuous Quantification (Chomsky 1982, 1995, Kratzer 1995, Kennedy 1997, Heim & Kratzer 1998, Fox 2000), the Principle of Full Interpretation (Chomsky 1986, 1995), and the Inclusiveness Condition (Chomsky 1995).

In addition, it seems that phonology and syntax can equally be considered resource-sensitive, i.e. lack weakening and contraction from a logical perspective, as outlined in Asudeh (2012: 98–99). This allows a deeper generalization about natural language as computation (Steedman 2007), namely that *natural language is resource-sensitive*. The claim is set out in the *Resource Sensitivity Hypothesis* (Asudeh 2012: 95). Where phonology and syntax contrast with semantics is not with respect to weakening and contraction, but rather with respect to commutativity. Phonology is strictly non-commutative, whereas syntax shows commutativity in some circumstances of free word order. This leaves two options. The partial commutativity of syntax can be captured by separating the syntax of structure from the syntax of composition, treating the syntactic module(s) autonomously, as in Glue Semantics. Alternatively, partial commutativity can be captured by not separating structural and compositional syntax and instead introducing a mechanism to the syntax–semantics interface that relaxes commutativity in what is otherwise a non-commutative system. An example of such a mechanism is the categorial modalities of Baldridge (2002).

3 Glue without LFG: Flexible composition

Linguistic meanings in Glue are encoded in *meaning constructors*. Meaning constructors are pairs of terms from two logics. These terms can be represented as $\mathcal{M}$ and G (where $\mathcal{M}$ is mnemonic for *meaning language* and G is mnemonic for *Glue logic*). These could be written in any conventional way for writing pairs, such as $\langle \mathcal{M}, G \rangle$, but most Glue work of the past couple of decades has written the pair using an uninterpreted colon as a pairing symbol:

(8) $\mathcal{M} : G$

The meaning language can be anything that supports the lambda calculus, such as the simply typed lambda calculus that is often used in linguistic semantics. However, more specialized lambda languages can be used, as in van Genabith & Crouch (1999), Bary & Haug (2011), and Lowe (2015), which all use Muskens's (1996) Compositional Discourse Representation Theory (CDRT) or Dalrymple et al. (2019: ch. 14), which uses Haug's (2014) partialized version, Partial Compositional DRT (PCDRT). The glue logic is a fragment of *linear logic* (Girard 1987). The glue logic specifies semantic composition based on a syntactic parse that instantiates the general terms in G to a specific syntactic structure. The meaning constructors thus serve as *premises* in a linear logic *proof* of the compositional semantics.

The linear logic implication connective, $\multimap$,[9] is the basis for the fundamental compositional rule of functional application. Functional application corresponds to linear implication elimination in natural deduction style:

(9) Functional application:
Implication elimination modus ponens

[9] This is the *multimap* symbol, but it is often referred to in Glue discourse as the *lollipop*.

$$\dfrac{\begin{matrix}\vdots \\ \beta : A \multimap B\end{matrix} \qquad \begin{matrix}\vdots \\ \alpha : A\end{matrix}}{\beta(\alpha) : B} \multimap_{\mathcal{E}}$$

The implication elimination rule is standard modus ponens. The rule is read as follows: given some sequence of proof steps, denoted by the vertical ellipsis, that lead to the meaning constructor $\beta : A \multimap B$ and given some sequence of proof steps that lead to $\alpha : A$, it is valid to conclude that $\beta(\alpha) : B$.

The Curry-Howard Isomorphism (CHI; Curry & Feys 1958, Howard 1980) determines the correspondence between the term to the left of the colon — a term from $\mathcal{M}$ — and the term to right of the colon — a term from G. The CHI puts logical formulas in correspondence with computational types. Here linear logic formulas are in correspondence with types in the lambda calculus.[10] The terms A, B in (9) are schematic for possibly complex formulas; α, β may similarly be complex terms.

The rule for linear implication introduction corresponds to functional abstraction.

(10) Functional abstraction:
Implication introduction — hypothetical reasoning

$$\dfrac{\begin{matrix}[\alpha : A]^1 \\ \vdots \\ \beta : B\end{matrix}}{\lambda\alpha.\beta : A \multimap B} \multimap_{\mathcal{I},1}$$

In this schema, a hypothesis is uniquely flagged with a numerical index. The fact that it is a hypothesis — i.e. not a premise encoded by a meaning constructor — is indicated by square brackets. If a conclusion can be derived through some series of proof steps (indicated by the vertical ellipsis), given the hypothesis, then we know that the hypothesis implies the conclusion: the hypothesis is discharged (as the antecedent of an implication with the conclusion as the consequent) and

[10] Some early papers in Glue (Dalrymple et al. 1993, Dalrymple, Lamping, Pereira, et al. 1995, 1997, Crouch & van Genabith 1999, van Genabith & Crouch 1999, Fry 1999a, Kehler et al. 1999) used a more ad-hoc method of relating the meaning terms to the Glue logic, but Dalrymple, Gupta, et al. (1997), Dalrymple, Gupta, et al. (1999) introduced the Curry-Howard approach to Glue, which is now standard. Kokkonidis (2008) introduced an alternant called *First-Order Glue* which has also proven influential in subsequent Glue literature (e.g., Bary & Haug 2011, Lowe 2014, Gotham 2018, Gotham & Haug 2018, Findlay 2019; see also Andrews 2010 for a related proposal).

its flag is withdrawn. In the meaning language, this corresponds to abstraction over the variable introduced on the meaning language side of the hypothesis.

Let's turn to a simple linguistic example:

(11) Blake called Alex.

Let us assume the following meaning constructor for the verb *called*, leaving tense aside:[11]

(12) $\lambda y.\lambda x.\mathbf{call}(y)(x) : a \multimap b \multimap c$

On the Glue side, c is mnemonic for *called*, a for *Alex*, and b for *Blake*. This meaning constructor would in fact be specified in some general form but instantiated relative to a particular syntactic structure. For now, let us just assume that some instantiation has given us the meaning constructor in (12). In Section 5 below, we'll see how to specify meaning constructors in general terms given LFG's usual f-description language.

Assuming that the lexical entries for *Alex* and *Blake* contribute meaning constructors that are instantiated to $\mathbf{alex} : a$ and $\mathbf{blake} : b$, we can construct the following proof, given (12); note that $\Rightarrow_\beta$ indicates β-reduction of a lambda term.

(13)
$$\dfrac{\mathbf{blake} : b \qquad \dfrac{\lambda y.\lambda x.\mathbf{call}(y)(x) : a \multimap b \multimap c \qquad \mathbf{alex} : a}{\lambda x.\mathbf{call}(\mathbf{alex})(x) : b \multimap c}{\scriptstyle \multimap_{\mathcal{E}}, \Rightarrow_\beta}}{\mathbf{call}(\mathbf{alex})(\mathbf{blake}) : c}{\scriptstyle \multimap_{\mathcal{E}}, \Rightarrow_\beta}$$

The meaning term in the conclusion is equivalent to $\mathbf{call}(\mathbf{blake}, \mathbf{alex})$ in the commonly used relational notation (Montague 1973).

Note that proofs are abstract mathematical objects that can be written down in various ways. This is quite apart from whatever convention or notation we choose for writing them down. For example, even holding constant our natural deduction notation, what is shown in (13) is just one of four ways to write down the single abstract normal form proof (Prawitz 1965). Writing the proof down imposes an order,[12] but since the Glue logic is commutative (see Section 2 for further details), all four written representations of the proof are equivalent.

[11]Note that the lambda term $\lambda y.\lambda x.\mathbf{call}(y)(x)$ is equivalent to the function **call** by η-equivalence in the lambda calculus. However, it is useful for the exposition below to present it in non η-reduced form.

[12]The *Alex* meaning constructor/premise must be written either to the right or left of the functional (verb) meaning constructor and similarly for the *Blake* meaning constructor/premise.

Given the commutativity of the Glue logic, the arguments of the function can be freely reordered (re-curried), as in (14) below, but still yield the appropriate meaning:

(14) $\lambda x.\lambda y.\mathbf{call}(y)(x) : b \multimap a \multimap l$

Example (15) below is a schematic demonstration of how this argument reordering works in a proof; the example abstracts away from the particular **call** function. The example also shows the implication introduction rule in action.

(15)

$$
\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\lambda y.\lambda x.f(y)(x) : a \multimap b \multimap c \qquad [v : a]^1}{\lambda x.f(v)(x) : b \multimap c}\multimap_{\mathcal{E}} \qquad [u : b]^2}{f(v)(u) : c}\multimap_{\mathcal{E}}}{\lambda v.f(v)(u) : a \multimap c}\multimap_{\mathcal{I},1}}{\lambda u.\lambda v.f(v)(u) : b \multimap a \multimap c}\multimap_{\mathcal{I},2}}{\lambda x.\lambda y.f(y)(x) : b \multimap a \multimap c}\Rightarrow_{\alpha}, \Rightarrow_{\alpha}
$$

The result is a reordered form of the original term but without any change in meaning, because the CHI ensures that the function's arguments in the meaning terms are also appropriately reordered. The α-equivalences, in which variables are renamed, are not strictly necessary, but have been added for full transparency. In general, given n arguments in the order $a_1 \ldots a_n$, a reverse order $a_n \ldots a_1$ can be obtained by a series of hypotheses on the arguments that are discharged in the order they were made. More generally, the arguments can be reordered in any order by mixing the order of hypothesis assumption and discharge.

4 The syntax–semantics interface: Autonomy of syntax

Glue rests on two general assumptions about the syntax–semantics interface:

1. The *logical syntax* of semantic composition (Fenstad et al. 1987) is distinct from the *structural syntax*. The syntax of linear logic proofs captures the logical syntax in Glue. Some separate syntactic framework, such as LFG, captures the structural syntax of categorially determined distribution, constituency, features, and local and non-local dependencies (i.e, *syntax* in the standard sense).

2. Logical syntax and structural syntax are systematically related through the instantiation of Glue meaning constructors.

These assumptions distinguish Glue from both *interpretive theories* of semantic composition and *parallel theories* of semantic composition. A well-known example of interpretive theories is Logical Form semantics (e.g., Heim & Kratzer 1998). The *description-by-analysis* semantics for LFG of Halvorsen (1983) is another example of an interpretive theory. Two well-known examples of parallel theories are Combinatory Categorial Grammar (e.g., Steedman & Baldridge 2011) and Type-Logical Categorial Grammar (e.g., Carpenter 1997).[13]

With respect to LF semantics, Glue's assumption of a separate level of structural syntax is similar. However, in its standard co-descriptive guise, Glue is distinct from LF semantics, because Glue does not assume that the syntactic structure in its entirety is the input to semantic interpretation. With respect to Categorial Grammar, we also see similarity and divergence. We see similarity in Glue's assumption of the pairing of functional application (the fundamental compositional operation) with terms that define complex categories implicationally.[14] However, Glue is also distinct from Categorial Grammar, because Glue does not assume that implicational categories are responsible for word order (hence their lack of directionality), but rather that there is a separate syntactic representation. In sum, Glue is a compositional semantic theory of a third kind. From a big picture perspective, Glue synthesizes certain aspects of LF semantics and Categorial Grammar, yet remains distinct from both these theories.

The assumptions, in 2 and 2 above, that began this section derive a strong notion of syntactic autonomy. Categorial Grammar makes the very strong assumption that syntax and semantics are isomorphic. This assumption entails that any semantic distinction must be the reflection of a syntactic distinction. LF semantics similarly assumes that any interpretive/semantic distinction must be due to an underlying syntactic distinction. In an interpretive semantic theory such as LF semantics, the needs of semantics dictate what's in the syntax, even if the things in question are syntactically questionable. The predicate abstraction/numerical nodes in Heim & Kratzer (1998: 186) are an example, since they require the addition of lambda operators to the syntactic tree. This is surprising from the perspective of semantic theory, since this means that *object* languages, i.e.

[13] Parallel theories are often discussed under the rubric of "rule-by-rule composition" (Bach 1976), but the *rule-by-rule* term is no longer accurate. The term originates in the paired syntactic/semantic rules of Montague (1973), which is now deprecated. This kind of theory is also sometimes referred to as "direct compositionality" (Barker & Jacobson 2007, Jacobson 2014), but this raises a number of issues (Asudeh 2006), so I do not favour that term.

[14] Categorial Grammar's slashes are directed implications. For example, X/Y states that one can conclude a category X conditional on there being a category Y to the right; in other words, X/Y means that Y → X yields X so long as Y is on the right of X.

the natural languages undergoing analysis, must in fact contain these logical operators, for which there is no compelling evidence (such as lexicalization in some language or other).

Quantifier scope ambiguity offers perhaps the most straightforward demonstration of the distinction between Glue on the one hand, and LF semantics and Categorial Grammar, on the other. Consider the following standard example:

(16) Everybody loves somebody.

The Glue logic computes two readings for this sentence, but *without* imputing a syntactic ambiguity, which seems structurally under-motivated; see s 6.1 for further details. This contrasts with both LF semantics and Categorial Grammar; these theories both require the two readings to be syntactically distinguished.

In the next section, I pair Glue with LFG as the syntactic framework in order to render these general points more specific. Although, LFG is the natural syntactic framework to choose, given the present venue and the fact that most Glue work has assumed an LFG syntax, see Section 1 above for a list of other syntactic frameworks that have been paired with Glue.

5 Glue with LFG: Syntax/semantics non-isomorphism

Consider the example in Figure 2, which shows the c-structures and f-structure for the sentence *I drank water* in Finnish and English.[15] The distinct c-structures capture the variation in syntactic realization between the two languages. In particular, they capture the fact that Finnish allows null subjects, unlike English. The f-structure shows that these distinct c-structures encode identical syntactic features and dependencies. Figure 3 shows the same structures with the arrows resolved. One way to solve the equations is to label all c-structure nodes that bear a down arrow with an f-structure variable. Instantiation of the metavariables ↑ and ↓ is arbitrary, barring accidental identity, and resolves the equalities (Bresnan et al. 2016: 54–58).

In both the Finnish and English c-structures, the mapping to OBJECT is contributed structurally by the annotation (↑OBJ) = ↓ on the NP daughter of V′. In the English c-structure, the mapping to SUBJECT is also contributed structurally, by the annotation (↑SUBJ) = ↓ on the DP in SpecIP. In contrast, the SUBJECT information is contributed morphologically in the Finnish c-structure. This distinction is reflected in the lexical entries in Table 1. Notice that the f-descriptions in

[15] I assume LFG's theory of *extended heads*, which allows the Finnish verb to be generated in I (Bresnan et al. 2016: ch. 6–7).

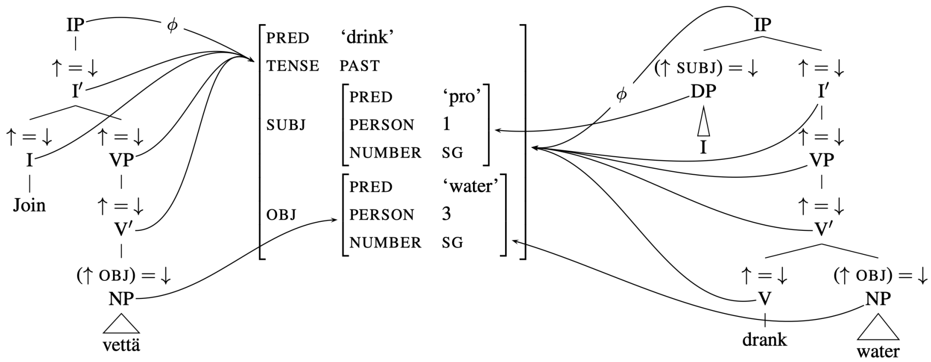


Figure 2: C-structures and f-structure for *I drank water* in Finnish and English (adapted from Asudeh & Toivonen 2015: 27; used with permission)

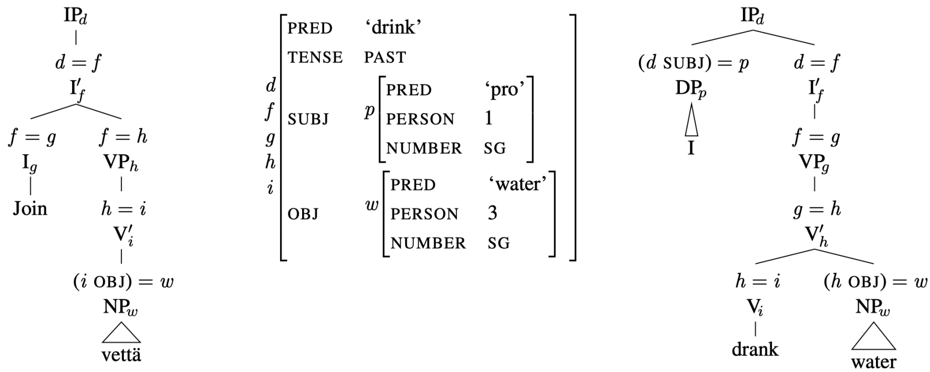


Figure 3: Finnish and English structures with ↑ and ↓ metavariables resolved (Asudeh 2022: 330; used with permission)

these lexical entries not only describe their lexical contributions to f-structure, but also have appropriate Glue meaning constructors that define the mappings to s(emantic)-structure and encode the composition of the head and its dependents as linear implications.[16] I have set tense aside in the semantics, but return to it in Section 6.3 below. The annotation σ on the arrows in the Glue meaning constructors indicates that these are the s-structure correspondents of the relevant f-structures. The σ correspondence function maps from f-structure to s-structure.

[16]The asterisk in the term for *vettä*/*water* is the cumulativity operator of Link (1983). It states that **water** is a mass term, although this is not important for our present purposes.

Table 1: Lexicons for *I drank water* in Finnish and English

Finnish			English		
join	I	$(\uparrow \textsc{pred}) = \textsc{drink}$ $(\uparrow \textsc{tense}) = \textsc{past}$ $(\uparrow \textsc{subj pred}) = \textsc{pro}$ $(\uparrow \textsc{subj person}) = 1$ $(\uparrow \textsc{subj number}) = \textsc{sg}$ $\textbf{speaker} : (\uparrow \textsc{subj})_\sigma$ $\textbf{drink} :$ $(\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$	*I*	D	$(\uparrow \textsc{pred}) = \textsc{pro}$ $(\uparrow \textsc{person}) = 1$ $(\uparrow \textsc{number}) = \textsc{sg}$ $\textbf{speaker} : \uparrow_\sigma$
			drank	V	$(\uparrow \textsc{pred}) = \textsc{drink}$ $(\uparrow \textsc{tense}) = \textsc{past}$ $\textbf{drink} :$ $(\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$
vettä	N	$(\uparrow \textsc{pred}) = \textsc{water}$ $(\uparrow \textsc{person}) = 3$ $(\uparrow \textsc{number}) = \textsc{sg}$ ${}^*\textbf{water} : \uparrow_\sigma$	*water*	N	$(\uparrow \textsc{pred}) = \textsc{water}$ $(\uparrow \textsc{person}) = 3$ $(\uparrow \textsc{number}) = \textsc{sg}$ ${}^*\textbf{water} : \uparrow_\sigma$

The up arrows in Table 1 are instantiated to the f-structure of the relevant pre-terminal node: g (Finnish *join*), w (Finnish *vettä*), p (English *I*), i (English *drank*), and w (English *water*).[17] However, we know from Figure 3 that $g = i = d$. So we can just use the mnemonic label d in all relevant cases. We can also take advantage of the equality $(d\ \textsc{subj}) = p$. We obtain the following collection of identical instantiated meaning constructors for each language:

(17) $\{\textbf{speaker} : p_\sigma, \textbf{drink} : w_\sigma \multimap p_\sigma \multimap d_\sigma, {}^*\textbf{water} : w_\sigma\}$

This yields a single normal form proof (i.e., minimal proof; Prawitz 1965) for the corresponding Finnish and English sentences, which can be presented in natural deduction format as follows (recall that order of premises on a proof line does not matter, since the Glue logic is commutative):

(18)

$$\frac{\textbf{speaker} : p_\sigma \qquad \dfrac{\textbf{drink} : w_\sigma \multimap p_\sigma \multimap d_\sigma \qquad {}^*\textbf{water} : w_\sigma}{\textbf{drink}({}^*\textbf{water}) : p_\sigma \multimap d_\sigma}\multimap_{\mathcal{E}}}{\textbf{drink}({}^*\textbf{water})(\textbf{speaker}) : d_\sigma}\multimap_{\mathcal{E}}$$

[17] In the case of the abbreviated (triangle) structures, there would be intervening nodes. But there would be a chain of ↑=↓ annotations between the word and the phrase it heads, so this is a harmless simplification.

6 Some applications of glue semantics

6.1 Quantifier scope

Let us return to the quantifier scope example in (16) above, repeated here as (19).

(19) Everybody loves somebody.

Glue's properties of autonomy of syntax and flexible composition allow (19) to be treated as *syntactically unambiguous* but *semantically ambiguous.*

I will not show the c-structure here, as the relevant syntactic representation is the single f-structure for (19) shown here, with mnemonic labels as usual:

(20)
$$
{}_{l}\left[\begin{array}{ll}
\textsc{pred} & \textsc{love} \\
\textsc{tense} & \textsc{pres} \\
\textsc{subj} & {}_{e}\left[\begin{array}{ll} \textsc{pred} & \textsc{everybody} \\ \textsc{person} & 3 \\ \textsc{number} & \textsc{sg} \end{array}\right] \\
\textsc{obj} & {}_{s}\left[\begin{array}{ll} \textsc{pred} & \textsc{somebody} \\ \textsc{person} & 3 \\ \textsc{number} & \textsc{sg} \end{array}\right]
\end{array}\right]
$$

The Glue meaning constructors in the lexical entries are shown in (21). Tense has again been set aside and it is again most transparent for expository purposes to show the meaning term for *loves* in non-η-reduced form (see footnote 11 on η-reduction).

(21)
everybody	D	$\lambda Q.\mathbf{every}(\mathbf{person}, Q) : \forall S.(\uparrow_\sigma \multimap S) \multimap S$
somebody	D	$\lambda Q.\mathbf{some}(\mathbf{person}, Q) : \forall S.(\uparrow_\sigma \multimap S) \multimap S$
loves	V	$\lambda y.\lambda x.\mathbf{love}(y)(x) : (\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma$

When we instantiate the meaning constructors in (21) relative to the f-structure in (20), we get:

(22)
$$
\begin{aligned}
\Gamma = \{ & \lambda y.\lambda x.\mathbf{love}(y)(x) : s \multimap e \multimap l, \\
& \lambda Q.\mathbf{every}(\mathbf{person}, Q) : \forall S.(e \multimap S) \multimap S, \\
& \lambda Q.\mathbf{some}(\mathbf{person}, Q) : \forall S.(s \multimap S) \multimap S \}
\end{aligned}
$$

The functions **every** and **some** are standard quantificational determiners from generalized quantifier theory (Montague 1973, Barwise & Cooper 1981, Keenan & Faltz 1985), with type $\langle\langle e,t\rangle,\langle\langle e,t\rangle,t\rangle\rangle$. The function **every** is defined as

$\lambda P.\lambda Q.P \subseteq Q$. The function **some** is defined as $\lambda P.\lambda Q.P \cap Q \neq \emptyset$. In these formulas, P is the set of entities that is the determiner's restriction and Q is the set of entities that is its scope. The quantifier $\lambda Q.\mathbf{every}(\mathbf{person}, Q)$ thus returns true if the set of people is a subset of its scope set. Similarly, the quantifier $\lambda Q.\mathbf{some}(\mathbf{person}, Q)$ returns true if the intersection of the set of people and its scope set is non-empty.

A comment is in order about the universal quantification symbol $\forall$ in the Glue terms for the quantifiers. This universal ranges over variables in the Glue logic. It allows the quantifier scope over *any* Glue logic dependency on the semantic correspondent of the quantifier. Asudeh (2005b: 393–394) discusses the interpretation of $\forall$ in linear logic. The key insight is that, given the resource sensitivity of linear logic, the universal means "any one", not "all". The function of the linear universal is to define *scope points* and its interpretation is not related to the quantificational force in the meaning language. Observe that **every** and **some** alike are associated with these linear universal scope terms, even though **some** has existential force.

The meaning constructors in (22) yield exactly two normal form/minimal proofs. These can be represented as in Figure 4 and Figure 5.[18] In other theories, quantifier scope ambiguity requires either a syntactic operation such as Quantifier Raising (QR) in Logical Form semantics (May 1977, 1985, Heim & Kratzer 1998) or a type shifting operation and corresponding categorial modification of some kind, as in Combinatory or Type-Logical Categorial Grammar semantics (Partee & Rooth 1983, Hendriks 1993). Thus, interpretive and parallel theories of composition alike impute a syntactic ambiguity to handle quantifier scope ambiguity.[19]

This contrasts with Glue Semantics. The fact that Glue assumes an independent level of syntax (autonomy of syntax) allows composition to be flexible (flexible composition), which in turn allows the theory to derive the two distinct scope readings without positing a syntactic ambiguity or type shift.

[18] The universal linear instantiation step is trivial, as in classical/intuitionistic logic. I have therefore not shown it explicitly. See Asudeh (2012: 396) for the rule.

[19] Jacobson (2014: ch. 14) offers a textbook comparison of the LF and CG approaches.

$$
\dfrac{\lambda Q.\mathbf{every}(\mathbf{person}, Q) : \forall S.(e \multimap S) \multimap S \qquad \dfrac{\dfrac{\lambda Q.\mathbf{some}(\mathbf{person}, Q) : \forall S.(s \multimap S) \multimap S \qquad \dfrac{\dfrac{\dfrac{\lambda y.\lambda x.\mathbf{love}(y)(x) : s \multimap e \multimap l \qquad [v : s]^1}{\lambda x.\mathbf{love}(v)(x) : e \multimap l}\,{\multimap_{\mathcal{E}}, \Rightarrow_\beta} \qquad [u : e]^2}{\mathbf{love}(v)(u) : l}\,{\multimap_{\mathcal{E}}, \Rightarrow_\beta}}{\lambda y.\mathbf{love}(y)(u) : s \multimap l}\,{\multimap_{\mathcal{I},1}, \Rightarrow_\alpha}}{\mathbf{some}(\mathbf{person}, \lambda y.\mathbf{love}(y)(u)) : l}\,{\multimap_{\mathcal{E}}, \forall_{\mathcal{E}}[l/S], \Rightarrow_\beta}}{\lambda x.\mathbf{some}(\mathbf{person}, \lambda y.\mathbf{love}(y)(x)) : e \multimap l}\,{\multimap_{\mathcal{I},2}, \Rightarrow_\alpha}}{\mathbf{every}(\mathbf{person}, \lambda x.\mathbf{some}(\mathbf{person}, \lambda y.\mathbf{love}(y)(x))) : l}\,{\multimap_{\mathcal{E}}, \forall_{\mathcal{E}}[l/S], \Rightarrow_\beta}
$$

Figure 4: Surface scope interpretation of *Everybody loves somebody*

$$
\dfrac{\lambda Q.\mathbf{some}(\mathbf{person}, Q) : \forall S.(s \multimap S) \multimap S \qquad \dfrac{\dfrac{\lambda Q.\mathbf{every}(\mathbf{person}, Q) : \forall S.(e \multimap S) \multimap S \qquad \dfrac{\lambda y.\lambda x.\mathbf{love}(y)(x) : s \multimap e \multimap l \qquad [v : s]^1}{\lambda x.\mathbf{love}(v)(x) : e \multimap l}\,{\multimap_{\mathcal{E}}, \Rightarrow_\beta}}{\mathbf{every}(\mathbf{person}, \lambda x.\mathbf{love}(v)(x)) : l}\,{\multimap_{\mathcal{E}}, \forall_{\mathcal{E}}[l/S], \Rightarrow_\beta}}{\lambda y.\mathbf{every}(\mathbf{person}, \lambda x.\mathbf{love}(y)(x)) : s \multimap l}\,{\multimap_{\mathcal{I},1}, \Rightarrow_\alpha}}{\mathbf{some}(\mathbf{person}, \lambda y.\mathbf{every}(\mathbf{person}, \lambda x.\mathbf{love}(y)(x))) : l}\,{\multimap_{\mathcal{E}}, \forall_{\mathcal{E}}[l/S], \Rightarrow_\beta}
$$

Figure 5: Inverse scope interpretation of *Everybody loves somebody*

6.2 Modification

Glue is similar to Categorial Grammar in offering an analysis of semantic *modification* such that modifiers are easily identifiable by their formal shape. For example, the nominal modification category in (23) has its Glue logic analog in (24) (leaving the meaning language aside):

(23) N/N

(24) $A_{\langle e,t\rangle} \multimap A_{\langle e,t\rangle}$

A nominal modifier is a functional category/type that takes a nominal category/type as an input and returns the same category/type as an output. The modificational semantics is captured on the meaning language side.

For example, a Glue meaning constructor for the attributive adjective *Finnish* would look like (25).

(25) $\lambda P \lambda x.P(x) \wedge \mathbf{finnish}(x) \;:\; (a_e \multimap b_t) \multimap (a_e \multimap b_t)$

Continuing the example, the common noun *city* would provide the $\langle e,t \rangle$ input to the main implication in (25), such that *Finnish city* would correspond to the following (composed) result:

(26) $\lambda x.\mathbf{city}(x) \wedge \mathbf{finnish}(x) \;:\; (a_e \multimap b_t)$

More generally, a modifier of any type corresponds to a meaning constructor with the following form:

(27) $\lambda f.\mathbf{mod}(f) \;:\; X \multimap X$

The function **mod** is a placeholder for whatever the semantic effect of the modifier is.

The property of syntax-semantics non-isomorphism, which allows a lexical item to contribute multiple meaning constructors, allows a natural and elegant analysis of so-called *recursive modification* (Kasper 1997). In a nominal like the following, the result we want is that it is apparently the case that the city in question is Finnish:

(28) apparently Finnish city

In other words, we somehow want to maintain a consistent semantics for *apparently* as a modifier, while nevertheless allowing it to fulfill this modificational role inside a nominal. This is despite the type clash between the modifier, which expects a proposition-forming type as input, and the adjective *Finnish*, which does not have this type. The adjective instead has the type of a modifier, i.e. a function on the type that the interpretation of *apparently* expects.

The solution in Glue is to associate predicative and attributive adjectives with the property denotation for the adjective, shown in the first line of (29), and to further add a general nominal modification meaning constructor to the lexical entry for the attributive adjective, as in the second line of (29).

(29) *Finnish* $\lambda x.\mathbf{finnish}(x) : v \multimap f$
$(\ \lambda Q \lambda P \lambda x.Q(x) \wedge P(x) : (v \multimap f) \multimap (a \multimap b) \multimap (a \multimap b) \ )$

The reader can verify that the combination of these two meaning constructors yields the meaning constructor in (25) above (with types omitted). The second meaning constructor is treated as optional to ensure that predicative uses of the adjective work as expected. Resource-sensitive composition ensures that a predicative occurrence of the adjective cannot use the second meaning constructor whereas an attributive occurence must use it.

The revised analysis allows recursive modification by a modifier like *apparently*, assuming that we have a meaning constructor like the following associated with *apparently*, suitably instantiated to an f-structure where *apparently* is in the ADJ set of *finnish*:

(30) *apparently* $\lambda P \lambda x.\mathbf{apparently}(P(x)) : (v \multimap f) \multimap (v \multimap f)$

The combination of this meaning constructor for *apparently* and the first meaning constructor in (29) then yields the following:

(31) $\lambda x.\mathbf{apparently}(\mathbf{finnish}(x)) : v \multimap f$

This is sufficient for a predicative occurrence, as in *Marimekko is apparently Finnish*.

For attributive occurrences, (31) then combines with the second meaning constructor in (29), which yields the desired result:

(32) $\lambda P \lambda x.\mathbf{apparently}(\mathbf{finnish}(x)) \wedge P(x) : (a \multimap b) \multimap (a \multimap b)$

This would then combine with the interpretation of *city* to yield the correct interpretation for, e.g., *The apparently Finnish city is nice.*

I leave aside here the natural extension that is necessary to fully capture recursive modification in examples like the following:

(33) apparently obviously Finnish

The extension just involves having two separate meaning constructors for the adverbial modifier *obviously* (and *apparently*, etc.), in order to make the system fully general, much as we have for the adjective *Finnish* in (29).

The first proposal for the extended modificational semantics presented here was in Dalrymple (2001: 255–274), to my knowledge. The most recent version of the LFG+Glue approach to modification, including recursive modification, is the subject matter of Dalrymple et al. (2019: ch. 13).

6.3 Tense

The basic approach to modification that was sketched at the beginning of Section 6.2 supports a simple account of tense as a modifier on a basic verb meaning, provided that we add a tense coordinate to verb meanings (for a review of approaches to tense in compositional semantics,see Grønn & von Stechow 2016).

Let us assume that a basic meaning constructor for a verb now looks like this:

(34) *sigh* $\lambda x \lambda t.\mathbf{sigh}(t, x) : \mathit{subj} \multimap \mathit{tense} \multimap \mathit{verb}$

Let's also assume, following Haug 2008, that u stands for utterance time (what Grønn & von Stechow 2016 denote as s^*, for speech time). Then we can capture simple present, past and future tense as follows, with the Glue logic instantiated suitably per the terms in (34):[20]

(35) a. PAST $\lambda P \lambda t.P(t) \wedge t \prec u : (\mathit{tense} \multimap \mathit{verb}) \multimap (\mathit{tense} \multimap \mathit{verb})$

b. PRESENT $\lambda P \lambda t.P(t) \wedge t = u : (\mathit{tense} \multimap \mathit{verb}) \multimap (\mathit{tense} \multimap \mathit{verb})$

c. FUTURE $\lambda P \lambda t.P(t) \wedge u \prec t : (\mathit{tense} \multimap \mathit{verb}) \multimap (\mathit{tense} \multimap \mathit{verb})$

This sort of account is obviously too simple, but it illustrates tense as a modifier. Note that I've presented the tenses "on their own" for maximal perspicuity, but in a lexicalist framework such as LFG, one would normally assume that tense-inflected forms are inserted in the syntax as words, formed morpholexically. That would just mean that, for example, the inflected form *sighed* would contribute both the meaning constructor in (34) and the one in (35a). Note also that I assume some kind of suitable eventual existential closure of the temporal variable.

One could also incorporate grammatical (as opposed to lexical) aspect in a similar, modificational manner. For analyses of tense and grammatical aspect in Glue Semantics, see Haug (2008), Bary & Haug (2011), and Lowe (2014, 2015).[21]

[20] These sorts of meanings assume a model of time as consisting of points, but it may well be preferable to think of time as consisting of intervals (Dowty 1979). An interval-based semantics poses no problem for tense in Glue Semantics per se, but I've chosen to keep things simple here.

[21] Some of this work assumes some version of event semantics (sketched in Section 6.4). However, event semantics is not necessary for a basic treatment of tense, as I've illustrated here.

6.4 Events

The first Glue analysis to incorporate event semantics (Davidson 1967, Parsons 1990, Champollion 2017) was never published (Fry 1999b, 2005). To my knowledge, the first major publications to use event semantics were Asudeh & Toivonen (2012) and Asudeh et al. (2013). Much like the analysis of tense sketched above, event semantics for Glue involves adding a dependency on an event variable. Moreover, work in event semantics in Glue has generally taken the Neo-Davidsonian approach of Parsons (1990), in which verbs (and other predicates that take event-arguments) denote functions from events to truth values, such that the arguments of the verb are actually modifiers of the event variable. For example, the sentences in (36) would receive an interpretation like (37), whereas the sentence in (38) would receive an interpretation like (39).[22]

(36) a. Sam hugged Max.

b. Max was hugged by Sam.

(37) $\exists e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = \mathbf{sam} \wedge \mathbf{patient}(e) = \mathbf{max}$

(38) Max was hugged.

(39) $\exists e \exists x.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = \mathbf{max}$

It can be observed from (37) and (39) that the event variable is eventually existentially closed. This is a standard assumption in event semantics.

Event semantics is a natural meaning language for Glue Semantics, because the event variable permits a highly factorized semantics, using LFG's *template* language (Dalrymple et al. 2004), which is designed to allow generalizations to be captured across grammatical elements, including meaning constructors. This in turn maximizes the analytic leverage offered by flexible composition and syntax/semantics non-isomorphism.

For example, the lexical entry for the verb *hugged* (again leaving tense aside) can capture its underlying semantic bivalence by encoding a dependency on a SUBJECT and OBJECT (as well as the event variable):[23]

(40) *hugged* $\lambda y \lambda x \lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = y$:
$obj \multimap subj \multimap event \multimap verb$

[22] It is also possible to treat verbs as generalized quantifiers over events (Champollion 2017, Coppock & Champollion 2020), but I'm not aware of any Glue work thus far that has taken this tack and it wouldn't make a difference to the sorts of simple cases sketched here.

[23] It has been common in Glue work on event semantics to use e, e', e'', etc., as variables over events, but a common convention in event semantics more generally is to use v, v', v'', etc. (e.g., Champollion 2017, Coppock & Champollion 2020).

We can take advantage of pervasive syncretism in the English passive participle here and assume that the meaning constructor in (40) is associated with the past tense and passive participle alike.

We can then treat the passive voice as contributing a modificational meaning constructor that remaps the arguments, as in (41). I again associate this with an abstract formative to gloss over details of lexicalization (for a related proposal, see Findlay 2019: 185–186).[24]

(41) PASSIVE $\lambda P \lambda x \lambda y . P(x)(y) : (obj \multimap subj \multimap verb) \multimap$
$subj \multimap obl \multimap verb$

Note that this entry requires implication elimination on the *event* term in the verb's meaning constructor and then reintroduction of the term (for eventual existential binding of the corresponding variable) after the passive modifier has composed with the verb's meaning constructor. We will shortly add a second meaning constructor to the entry for PASSIVE, but this one suffices to capture the truth-conditional equivalence of (36a–b) (which is not to say that they are information-structurally equivalent).

The result of combining the meaning constructor in (41) with the one in (40) is passive *hugged*:

(42) *hugged*+PASSIVE $\lambda x \lambda y \lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = y \wedge \mathbf{patient}(e) = x :$
$subj \multimap obl \multimap event \multimap verb$

In other words, the passive voice modifies the meaning of *hugged* such that the passive subject corresponds to the logical object (the patient in this case) and passive *by*-phrase corresponds to the logical subject (the agent in this case).[25] Figure 6 shows the proof for (36b). The reader can verify that the result is the same interpretation as that of (36a). The interpretation for (36a,b) is shown in (37) above.

But what of the short passive in (38)? Here we can leverage optionality and the properties of resource-sensitive composition and syntax/semantics non-isomorphism to naturally extend the analysis. We simply add an optional meaning constructor to (41), such that the revised lexical entry is as follows:

[24] Note that the treatment sketched here uses mnemonics for f-structure grammatical functions, like *subj*, in the Glue terms. However, actual Glue work in this vein uses Glue terms defined with respect to argument structure, as sketched in the next section. See Asudeh & Giorgolo (2012: 75–76) and Asudeh et al. (2014: 77ff.) for further details.

[25] I have implicitly assumed in my choice of mnemonic, *obl*, that the *by*-phrase is an OBLIQUE, but nothing hinges on this. The same term works if it is treated as an ADJUNCT, although its mnemonic function is obscured.

$$
\begin{prooftree}
\AxiomC{$\begin{array}{l}\textit{\textbf{hugged}}\\ \lambda y \lambda x \lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = y :\\ \mathit{obj} \multimap \mathit{subj} \multimap \mathit{event} \multimap \mathit{verb}\end{array}$}
\AxiomC{$[u : \mathit{obj}]^1$}
\RightLabel{$\multimap_{\mathcal{E}}$}
\BinaryInfC{$\begin{array}{l}\lambda x \lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = u :\\ \mathit{subj} \multimap \mathit{event} \multimap \mathit{verb}\end{array}$}
\AxiomC{$[v : \mathit{subj}]^2$}
\RightLabel{$\multimap_{\mathcal{E}}$}
\BinaryInfC{$\lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = v \wedge \mathbf{patient}(e) = u : \mathit{event} \multimap \mathit{verb}$}
\AxiomC{$[e' : \mathit{event}]^3$}
\RightLabel{$\multimap_{\mathcal{E}}$}
\BinaryInfC{$\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u : \mathit{verb}$}
\RightLabel{$\multimap_{\mathcal{I},2}$}
\UnaryInfC{$\lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u : \mathit{subj} \multimap \mathit{verb}$}
\RightLabel{$\multimap_{\mathcal{I},1}$}
\UnaryInfC{$\begin{array}{l}\lambda u \lambda v.\mathbf{hug}(e') \wedge\\ \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u :\\ \mathit{obj} \multimap \mathit{subj} \multimap \mathit{verb}\end{array}$}
\AxiomC{$\begin{array}{l}\textsc{passive}\\ \lambda P \lambda x \lambda y.P(x)(y) :\\ (\mathit{obj} \multimap \mathit{subj} \multimap \mathit{verb}) \multimap\\ \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}\end{array}$}
\RightLabel{$\multimap_{\mathcal{E}}$}
\BinaryInfC{$(\lambda P \lambda x \lambda y.P(x)(y))(\lambda u \lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u) : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}$}
\RightLabel{$\Rightarrow_{\beta}$}
\UnaryInfC{$\lambda x \lambda y.(\lambda u \lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u)(x)(y) : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}$}
\RightLabel{$\Rightarrow_{\beta}$}
\UnaryInfC{$\lambda x \lambda y.(\lambda v \lambda e'.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = x)(y) : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}$}
\RightLabel{$\Rightarrow_{\beta}$}
\UnaryInfC{$\begin{array}{l}\lambda x \lambda y \lambda e'.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = y \wedge \mathbf{patient}(e') = x :\\ \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}\end{array}$}
\AxiomC{$\begin{array}{l}\textit{\textbf{Max}}\\ \mathbf{max} :\\ \mathit{subj}\end{array}$}
\RightLabel{$\multimap_{\mathcal{E}}$}
\BinaryInfC{$\begin{array}{l}\lambda y.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = y \wedge \mathbf{patient}(e') = \mathbf{max} :\\ \mathit{obl} \multimap \mathit{verb}\end{array}$}
\AxiomC{$\begin{array}{l}\textit{\textbf{by Sam}}\\ \mathbf{sam} :\\ \mathit{obl}\end{array}$}
\RightLabel{$\multimap_{\mathcal{E}}$}
\BinaryInfC{$\mathbf{hug}(e') \wedge \mathbf{agent}(e') = \mathbf{sam} \wedge \mathbf{patient}(e') = \mathbf{max} : \mathit{verb}$}
\RightLabel{$\multimap_{\mathcal{I},3}$}
\UnaryInfC{$\lambda e'.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = \mathbf{sam} \wedge \mathbf{patient}(e') = \mathbf{max} : \mathit{event} \multimap \mathit{verb}$}
\RightLabel{$\Rightarrow_{\alpha}$}
\UnaryInfC{$\lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = \mathbf{sam} \wedge \mathbf{patient}(e) = \mathbf{max} : \mathit{event} \multimap \mathit{verb}$}
\RightLabel{$\exists_{\mathit{event}}$}
\UnaryInfC{$\exists e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = \mathbf{sam} \wedge \mathbf{patient}(e) = \mathbf{max} : \mathit{verb}$}
\end{prooftree}
$$

Figure 6: Proof for passive (36b), *Max was hugged by Sam*

(43) PASSIVE

$$
\begin{aligned}
&\lambda P \lambda y \lambda x.P(x)(y) : (\mathit{obj} \multimap \mathit{subj} \multimap \mathit{verb}) \multimap\\
&\qquad\qquad\qquad\qquad \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb})\\
&(\ \lambda P \exists x.P(x) : (\mathit{obl} \multimap \mathit{verb}) \multimap \mathit{verb}\ )
\end{aligned}
$$

The optional entry allows the passive to also contribute a second meaning constructor that existentially binds the subject argument. If there is an actual subject resource, though, as in the long passive in (36b), resource sensitivity ensures that the optional meaning constructor cannot be used, because then the actual subject resource would go unused. Figure 7 shows the proof for (36b). The reader can verify that the result is the same interpretation as that of (38), shown in (39) above.

The use of event semantics in LFG+Glue has become especially common in a thread of work on argument structure, the topic that we turn to next.

6.5 Argument structure

There is a prominent strand of work in Glue Semantics on argument structure and mapping theory (i.e., the realization of underlying arguments in the syntax). Representative work in this vein includes Arnold & Sadler (2013), Asudeh & Giorgolo (2012), Asudeh et al. (2014), Asudeh (2021), Findlay (2014, 2016, 2020), Lowe

hugged
$\lambda y \lambda x \lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = y :$
$\mathit{obj} \multimap \mathit{subj} \multimap \mathit{event} \multimap \mathit{verb}$ $\quad [u : \mathit{obj}]^1$

$$\frac{}{\lambda x \lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = u : \mathit{subj} \multimap \mathit{event} \multimap \mathit{verb}} \multimap_{\mathcal{E}} \quad [v : \mathit{subj}]^2$$

$$\frac{}{\lambda e.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = v \wedge \mathbf{patient}(e) = u : \mathit{event} \multimap \mathit{verb}} \multimap_{\mathcal{E}} \quad [e' : \mathit{event}]^3$$

$$\frac{}{\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u : \mathit{verb}} \multimap_{\mathcal{E}}$$

$$\frac{}{\lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u : \mathit{subj} \multimap \mathit{verb}} \multimap_{\mathcal{I},2}$$

$$\frac{}{\lambda u \lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u : \mathit{obj} \multimap \mathit{subj} \multimap \mathit{verb}} \multimap_{\mathcal{I},1}$$

PASSIVE
$\lambda P \lambda x \lambda y.P(x)(y) :$
$(\mathit{obj} \multimap \mathit{subj} \multimap \mathit{verb}) \multimap \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}$

$$\frac{}{(\lambda P \lambda x \lambda y.P(x)(y))(\lambda u \lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u) : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}} \multimap_{\mathcal{E}}$$

$$\frac{}{\lambda x \lambda y.(\lambda u \lambda v.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = u)(x)(y) : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}} \Rightarrow_{\beta}$$

$$\frac{}{\lambda x \lambda y.(\lambda v \lambda e'.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = v \wedge \mathbf{patient}(e') = x)(y) : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}} \Rightarrow_{\beta}$$

$$\frac{}{\lambda x \lambda y \lambda e'.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = y \wedge \mathbf{patient}(e') = x : \mathit{subj} \multimap \mathit{obl} \multimap \mathit{verb}} \Rightarrow_{\beta}$$

Max
$\mathbf{max} : \mathit{subj}$

$$\frac{}{\lambda y.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = y \wedge \mathbf{patient}(e') = \mathbf{max} : \mathit{obl} \multimap \mathit{verb}} \multimap_{\mathcal{E}}$$

PASSIVE
$\lambda P \exists x.P(x) :$
$(\mathit{obl} \multimap \mathit{verb}) \multimap \mathit{verb}$

$$\frac{}{(\lambda P \exists x.P(x))(\lambda y.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = y \wedge \mathbf{patient}(e') = \mathbf{max}) : \mathit{verb}} \multimap_{\mathcal{E}}$$

$$\frac{}{\exists x.(\lambda y.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = y \wedge \mathbf{patient}(e') = \mathbf{max})(x) : \mathit{verb}} \Rightarrow_{\beta}$$

$$\frac{}{\exists x.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = x \wedge \mathbf{patient}(e') = \mathbf{max} : \mathit{verb}} \Rightarrow_{\beta}$$

$$\frac{}{\lambda e' \exists x.\mathbf{hug}(e') \wedge \mathbf{agent}(e') = x \wedge \mathbf{patient}(e') = \mathbf{max} : \mathit{event} \multimap \mathit{verb}} \multimap_{\mathcal{I},3}$$

$$\frac{}{\lambda e \exists x.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = \mathbf{max} : \mathit{event} \multimap \mathit{verb}} \Rightarrow_{\alpha}$$

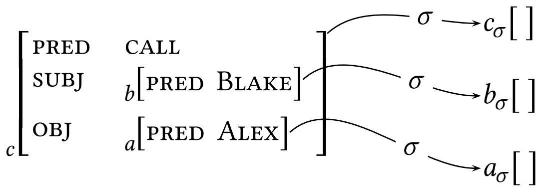
$$\frac{}{\exists e \exists x.\mathbf{hug}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = \mathbf{max} : \mathit{event} \multimap \mathit{verb}} \exists_{\mathit{event}}$$

Figure 7: Proof for short passive (38), *Max was hugged*

(2016, 2019), Lowe & Birahimani (2019), Przepiórkowski (2017), and Lovestrand (2020).

However, before turning to the Glue approach to argument structure, it is worth presenting some of the background that led to it, because it highlights another issue in Glue Semantics that has concerned some researchers. The substance of the worry can be straightforwardly summarized: What are the identity conditions for empty semantic structures? In other words, if a semantic structure is an attribute value matrix of some kind, as assumed from quite early on in the development of Glue Semantics (Dalrymple, Gupta, et al. 1999, Dalrymple 2001), how can there be *distinct* empty s-structures, since an empty AVM seems to correspond to the empty set, which is unique (Kokkonidis 2008, Findlay 2021).

(44)



One possible solution to the empty s-structure problem is to make the labelling part of the definition of the structure. In other words, if a standard attribute-value matrix is a finite set of attribute-value pairs (see, e.g., Bresnan et al. 2016: 44), then let us define an s-structure as a finite set of pairs, where the first member of each pair is a string (a unique label) and the second member of each pair is a (possibly empty) AVM. In that case, it's clear that the s-structure $\{\langle a_\sigma, \varnothing \rangle\}$ does not equal the s-structure $\{\langle b_\sigma, \varnothing \rangle\}$, even if both of them have the empty AVM as their second coordinate.

However, another issue with the sort of s-structure in (44) is that it's really not a structure at all, since the parts are not connected. In other words, what we have in (44) is really *three* s-structures, not a single one. This does not make a substantive difference to the kinds of proofs one can do in Glue Semantics, but it is a bit strange from a general LFG-theoretic perspective, as we would expect all the modules in the Correspondence Architecture to be structures and all of the ones that have been proposed, aside from the version of s-structure above, indeed are structures.

Asudeh & Giorgolo (2012) solve this last problem by offering a connected s-structure that also fulfills the role of a(rgument)-structure (Butt et al. 1997) in the Correspondence Architecture. Not only does this eliminate the need for a-structure as a separate module in the architecture, it also relates argument structure and mapping theory more strongly to compositional semantics, as the locus for both is now s-structure. Figure 8 shows the Asudeh & Giorgolo analysis for (45).

(45) Kim ate at noon.

The verb *ate* is semantically bivalent, since it entails that there is something that has been eaten, but it can nevertheless be syntactically intransitive (Asudeh & Giorgolo 2012: 71). This is reflected in the analysis in Figure 8. There is no OBJECT in the f-structure, but there are two arguments in the connected s-structure, which also serves as a representation of argument structure.

The solution to the syntax/semantics mismatch for the verb *ate* is to allow the verb itself to contribute an optional second meaning constructor that existentially closes the dependency on the second argument:[26]

[26]Intransitive uses of semantically bivalent verbs also trigger presuppositions about the implicit argument (Fillmore 1986); e.g., *Kim ate at noon* presupposes that what Kim ate is food (for Kim). I do not attempt to model this here, but see Asudeh & Giorgolo (2012) and Asudeh (2021) for some further discussion.

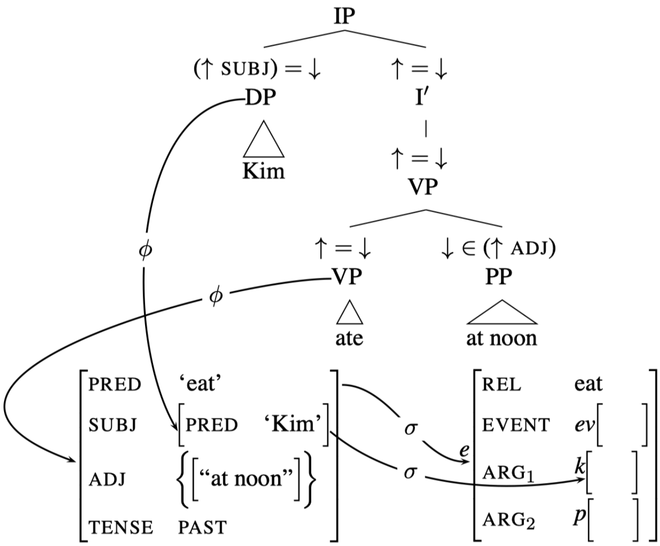


Figure 8: *Kim ate at noon* (Asudeh & Giorgolo 2012: 72; used with permission)

(46) *ate* $\lambda y \lambda x \lambda e.\mathbf{eat}(e) \wedge \mathbf{agent}(e) = x \wedge \mathbf{patient}(e) = y$:
$obj \multimap subj \multimap event \multimap verb$
$(\ \lambda P \exists x.P(x) \ : \ (obj \multimap verb) \multimap verb \ )$

This treatment is similar to the one for the passive in (43). Note that this is a simplification of the actual approach in Asudeh & Giorgolo (2012) and Asudeh et al. (2014), because in those approaches the Glue logic terms are defined using ARG features at s-structure, which allows the analysis to more naturally interact properly with argument alternations.

6.6 Multiword expressions

Multiword expressions (MWEs) are a challenge to a lexicalist theory like LFG, because they show a mixture of idiomaticity and productivity in both their syntax and semantics (Findlay 2019: ch. 1). On the one hand, we find expressions like *by and large* which are idiosyncratic in both their syntax (apparently a coordination of a preposition and an adjective) and semantics (the expression means something similar to the adverb *mostly*, but this can't be compositionally obtained from the usual meanings of its parts). On the other hand, we find expressions like *spill the beans*, which are syntactically unexceptional and possibly yield to a kind of transpositional semantic analysis in which ⟦*spill*⟧ = ⟦*reveal*⟧ and ⟦*the beans*⟧ = ⟦*the secret*⟧. Nevertheless, even with this MWE we see evidence of particular syntactic and semantic restrictions. For example, the object is necessarily the definite plural *beans* and other forms are either excluded entirely (e.g., #*a bean* or #*the peas*) or else seem at best like metalinguistic word-play (e.g., *the legumes*).

In short, MWEs are challenging because they are like words in the sense that they seem to be lexically stored expressions but are like phrases in having syntactic parts and, in some cases, these parts seem to be visible to syntactic operations. For example, in *It's too late: the beans have already been spilled*, the MWE has been passivized and one part is modified by an adverbial. For a lexicalist theory, simultaneously capturing these lexical and non-lexical properties of MWEs is difficult. Indeed, in order to account for this mixture of lexical and syntactic properties, Findlay (2019) replaces the c-structural part of standard LFG with Tree-Adjoining Grammar (TAG; Joshi et al. 1975, Abeillé & Rambow 2000), which allows expressions to be associated with trees in the lexicon, rather than with a simple category. TAG allows these trees to then be inserted or adjoined in the phrasal syntax. Findlay calls the resulting theory *Lexicalised LFG*, in a nod to Lexicalized TAG (Schabes et al. 1988), because it allows lexicalization of syntactic structures as TAG trees while maintaining LFG's standard separate level of f-structure and a mapping between the TAG-based c-structures and the f-structures.

No matter how one captures the syntax of MWEs, the syntax/semantics non-isomorphism of Glue Semantics naturally captures their syntax/semantics mismatches and idiomaticity. For example, Figure 9 shows Findlay's *lexical* entry for *by and large*. It is an adjunct tree, since this is a modifier. The meaning of *by-and-large* is captured by the call to a template, @By-And-Large-Meaning, but we can simplify things as in (47).

(47) *by and large* $\lambda P \lambda x.\mathbf{mostly}(P(x)) : (subj \multimap verb) \multimap (subj \multimap verb)$

This is a relatively straightforward example. For more complex examples, see Findlay (2019).

In more recent work, Findlay (2021) has adopted a different formalization of Glue in order to account for MWEs that show form flexibility as long as some kind of core meaning is maintained, like in the following:

(48) a kick up the bum/backside/bottom/buttocks/ass/heinie/keister/booty/…

In this MWE, any word that denotes ⟦*bum*⟧ would seem to do, no matter its form, but anything that doesn't denote ⟦*bum*⟧ doesn't seem to have the idiomatic 'motivational' reading (e.g., #*crotch*).

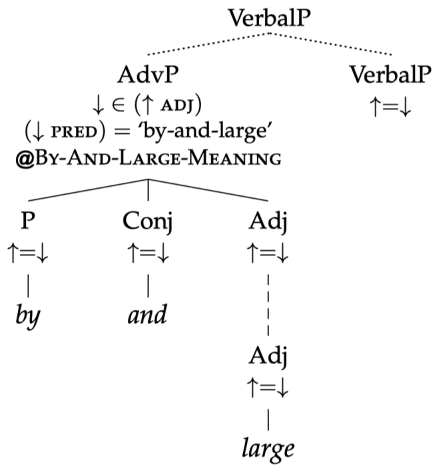


Figure 9: Lexical entry for *by and large* (Findlay 2019: 265; used with permission)

6.7 Anaphora

Anaphora has been a topic of long-standing interest in Glue Semantics. A recent LFG+Glue treatment and overview of previous literature is given in Dalrymple et al. (2019: ch. 14). Their treatment is a fairly sophisticated one that builds on recent work by Haug (2014) and Dalrymple et al. (2018). Here I present a simpler overview that summarizes the approach in Dalrymple, Lamping, Pereira, et al. (1997) and Asudeh (2004, 2012).

The property of flexible composition means that Glue can provide a variable-free treatment of anaphora, but without requiring that the anaphoric dependency be passed through all intervening material between the anaphor and its antecedent (in the intra-sentential case), as in non-commutative Categorial Grammar approaches (Jacobson 1999 et seq.). The simplest way to capture this would be through an implicational meaning constructor as in (49). I again associate the meaning constructor with an abstract formative to leave aside other aspects of particular personal pronouns, such as person, number, gender.

(49) ANAPHOR $\lambda y.y$: $\mathit{antecedent} \multimap \mathit{anaphor}$

However, there is a problem with a treatment this simple, because of resource-sensitive composition. If the anaphor consumes the antecedent resource, then the antecedent would no longer be available for composition. This means that whatever function takes the antecedent's denotation as an actual argument can no longer have its resource-sensitive compositional requirements satisfied. There would be no valid proof.

In order to remedy this, a simple solution is to slightly expand the fragment of linear logic that serves as the Glue logic. We add the *multiplicative conjunction* operator, ⊗, which does tensor/pair formation. The meaning constructor in (49) is then revised as follows:

(50) ANAPHOR $\lambda y.y \times y$: $antecedent \multimap (antecedent \otimes anaphor)$

The anaphor is still a function on its antecedent, but it now returns both its own resource and the antecedent resource.

On this sort of approach to anaphora, the multiplicative conjunction ⊗ is only ever introduced lexically (much as is the linear logic universal for scope points; see above). Therefore we just need to add the elimination rule for this connective, which is the following:

(51) Structured functional application:
Multiplicative conjunction elimination — pairwise substitution

$$\dfrac{\begin{array}{c}\vdots\\ \alpha : A \otimes B\end{array} \qquad \begin{array}{c}[\beta : A]^1 \quad [\gamma : B]^2\\ \vdots \qquad\quad \vdots\\ \delta : C\end{array}}{\text{let } \alpha \text{ be } \beta \times \gamma \text{ in } \delta : C}\otimes_{\mathcal{E},1,2}$$

The *let* type constructor performs pairwise substitution for the variables x, y in the result.

This is still quite abstract, so it is probably helpful to look at example (52) and its accompanying proof in Figure 10, both from Asudeh (2012: 84).[27]

(52) Thora said she giggled.

For a fuller treatment of anaphora that extends to inter-sentential cases, see Haug & Dalrymple (2020) and Dalrymple & Haug (2022).

7 Conclusion

Glue Semantics is a general framework for semantic composition and the syntax–semantics interface. The focus here has been on Glue for LFG, typically known

[27] Note that I have left out the $\multimap_{\mathcal{E}}$ annotations in the proof to reduce clutter. Also, the following mnemonic Glue terms are used: t for the term contributed by *Thora* (which is both the antecedent of the pronoun and the subject of the sentence), p for pronoun, g for *giggle*, and s for *said*.

$$
\dfrac{
  \dfrac{
    \dfrac{
      \begin{array}{l}\textbf{\textit{Thora}}\\ \textbf{thora} :\\ t\end{array}
      \quad
      \begin{array}{l}\textbf{\textit{she}}\\ \lambda z.z \times z :\\ t \multimap (t \otimes p)\end{array}
    }{\textbf{thora} \times \textbf{thora} : t \otimes p}\multimap_{\mathcal{E}}
    \quad
    \dfrac{
      \dfrac{[x : t]^1 \quad \begin{array}{l}\textbf{\textit{said}}\\ \lambda u \lambda q.\textbf{say}(u,q) :\\ t \multimap g \multimap s\end{array}}{\lambda q.\textbf{say}(x,q) : g \multimap s}\multimap_{\mathcal{E}}
      \quad
      \dfrac{[y : p]^2 \quad \begin{array}{l}\textbf{\textit{giggled}}\\ \lambda x.\textbf{giggle}(x) :\\ p \multimap g\end{array}}{\textbf{giggle}(y) : g}\multimap_{\mathcal{E}}
    }{\textbf{say}(x, \textbf{giggle}(y)) : s}\multimap_{\mathcal{E}}
  }{\text{let } \textbf{thora} \times \textbf{thora} \text{ be } x \times y \text{ in } \textbf{say}(x, \textbf{giggle}(y)) : s}\otimes_{\mathcal{E},1,2}
}{\textbf{say}(\textbf{thora}, \textbf{giggle}(\textbf{thora})) : s}\Rightarrow_{\beta}
$$

Figure 10: Proof for intra-sentential anaphoric reading of (52), *Thora said she giggled*

as LFG+Glue. Four key properties of Glue Semantics are resource-sensitive composition, flexible composition, autonomy of syntax, and syntax/semantics non-isomorphism (Asudeh 2022: 324). Analyses in Glue Semantics are highly constrained by the resource logic *linear logic*, a fragment of which serves as the Glue logic for semantic composition. Although resource-sensitive composition constrains semantic composition, it allows composition to be commutative. This yields the property of flexible composition: The logical syntax of composition is not identical to the structural syntax. From this we can derive the property of autonomy of syntax: Syntax and semantics are separate levels. From this we lastly derive the property of syntax/semantics non-isomorphism: Whatever the basic elements of structural syntax are taken to be (words in the case of standard LFG), these elements may make multiple or no contributions to semantic composition. The best source for further details about Glue analyses of particular phenomena and further Glue references is Dalrymple et al. (2019). However, I've listed a representative sample of Glue work by topic in the appendix.

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List of Glue work by topic

Here is a representative sample of work in Glue Semantics, organized alphabetically by topic:[28]

- Anaphora
  Dalrymple, Lamping, Pereira, et al. (1997), Asudeh (2004, 2005b, 2012), Bary & Haug (2011), Belyaev & Haug (2014), Dalrymple et al. (2019: ch. 14), Haug & Dalrymple (2020), Dalrymple & Haug (2022)

- Argument structure and argument realization
  Asudeh & Giorgolo (2012), Asudeh et al. (2014), Asudeh (2021), Arnold & Sadler (2013), Findlay (2014, 2016, 2020), Lowe (2016, 2019), Lowe & Birahimani (2019), Przepiórkowski (2017), Lovestrand (2020)

- Category theory for natural language semantics
  Giorgolo & Asudeh (2012a,b), Giorgolo & Asudeh (2014a,b), Asudeh & Giorgolo (2016, 2020)

- Complex predicates
  Andrews (2007, 2018), Lowe (2016, 2019), Lowe & Birahimani (2019), Lovestrand (2020)

- Computational applications and tools (open source)[29]
  Crouch et al. (1986), Lev (2007), Meßmer & Zymla (2018), Dalrymple et al. (2020), Zymla (2021a,b,c)

- Concomitance
  Haug (2009)

- Constructions
  Asudeh et al. (2008, 2013), Asudeh & Toivonen (2014)

- Control/equi and raising
  Asudeh (2005a), Haug (2013), Dalrymple et al. (2019: ch. 15)

- Conventional implicature
  Asudeh (2004: ch. 4), Potts (2005), Arnold & Sadler (2010, 2011), Giorgolo & Asudeh (2012a)

[28] My apologies to anyone whose work I have inadvertently omitted.
[29] Zymla's (2021c) tool goes with the XLE tools for computational implementation and testing of LFG grammars (Crouch, Dalrymple, Kaplan, King, Maxwell & Newman 2011).

- Coordination
  Kehler et al. (1999), Asudeh & Crouch (2002a), Dalrymple et al. (2019: ch. 16)

- Copy raising
  Asudeh (2004, 2012), Asudeh & Toivonen (2007, 2012)

- Distance distributivity
  Przepiórkowski (2014a,b, 2015)

- Dynamic semantics
  Crouch & van Genabith (1999), van Genabith & Crouch (1999), Dalrymple et al. (2019: ch. 14)

- Event semantics
  Fry (2005), Asudeh & Giorgolo (2012), Asudeh & Toivonen (2012), Asudeh et al. (2013), Asudeh et al. (2014)

- Evidentiality
  Asudeh & Toivonen (2017)

- Formal foundations
  Dalrymple, Gupta, et al. (1999), Dalrymple, Lamping, Pereira, et al. (1999), Dalrymple, Lamping, Pereira, et al. (1997); Asudeh (2004, 2012: ch. 5) Kokkonidis (2008), Andrews (2008, 2010), Findlay (2021))

- Fragments
  Asudeh (2012: ch. 11)

- Idioms and multiword expressions
  Findlay (2019, 2021)

- Incorporation
  Asudeh (2007), Baker et al. (2010)

- Information structure
  Dalrymple & Nikolaeva (2011), Mycock (2006), Morrison (2017)

- Intensionality
  Dalrymple, Lamping, Pereira, et al. (1997), Asudeh & Toivonen (2012)

- Modification
  Dalrymple et al. (1993), Dalrymple, Lamping, Pereira, et al. (1999), Dalrymple (2001), Asudeh & Crouch (2002b), Andrews (2018), Dalrymple et al. (2019: ch. 13)

- Negative polarity items
  Fry (1999a)

- Perception verbs
  Asudeh & Toivonen (2007, 2012), Asudeh (2012), Camilleri et al. (2014)

- Predication
  Dalrymple (2001), Asudeh & Crouch (2002b), Dalrymple et al. (2019: ch. 13)

- Quantification and scope
  Dalrymple, Lamping, Pereira, et al. (1997), Dalrymple et al. (2019: ch. 8)

- Relational nouns
  Asudeh (2005b)

- Resumptive pronouns
  Asudeh (2004, 2005b, 2011, 2012), Camilleri & Sadler (2011)

- Split nominals
  Kuhn (2001)

- Tense and aspect
  Haug (2008), Bary & Haug (2011), Lowe (2014, 2015), Belyaev (2020)

- Unbounded dependencies
  Asudeh (2012), Dalrymple et al. (2019: ch. 17)

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Chapter 7

Morphology in LFG

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Lexical-Functional Grammar has been consistent over the past four+ decades about its conception of syntactic structure and the sorts of rules that license it. However, despite being a highly lexicalist model of grammar, LFG has not developed a similarly consistent model of morphology. LFG has in fact assumed a variety of different models of morphology and interfaces with distinct 'morphological' modules and theories in this time. This is perhaps because LFG early on solved the problem of how morphology and syntax can communicate in a common formal language — the language of functional descriptions, which can be both associated with words and their parts and with syntactic elements. We first introduce some important concepts from morphological theory. We then look at some early LFG analyses which treated morphology *incrementally*. Subsequently, we review work on the syntax–morphology interface in LFG. We end with a discussion of *realizational* approaches to morphology in LFG.

1 Introduction

Lexical-Functional Grammar has been fairly consistent over the past more than four decades about its conception of syntactic structure and the sorts of rules that license it. However, despite being a highly lexicalist model of grammar, LFG has not developed a similarly consistent model of word-formation. LFG has in fact assumed a variety of different models of word-formation and interfaces with distinct 'morphological' modules and theories in this time. This is perhaps because

Ash Asudeh, Paul B. Melchin & Daniel Siddiqi. Forthcoming. Morphology. In Mary Dalrymple (ed.), *Handbook of Lexical Functional Grammar*. Berlin: Language Science Press.

LFG early on solved the problem of how morphology and syntax can communicate in a common formal language — the language of *functional descriptions*, which can be both associated with words and their parts and with syntactic elements. Together with the Lexicalist Hypothesis (Lapointe 1980, Chomsky 1970, Bresnan et al. 2016: 92), this entailed that syntactic terminals are morphologically complete words, with possibly complex associated f-descriptions, but the theory did not have to really say anything about the exact mechanism for word formation or how contributions were made to complex f-descriptions by specific parts of words. In addition, LFG has distributed what might be considered aspects of word-formation to various components besides a lexicon, including for example prosodic or phonological structures (Dalrymple & Mycock 2011, Bögel 2015).

In this context, it is perhaps better to start this chapter with a brief overview of some of the range of variation in morphological theory so that we can better situate LFG in the landscape of morphological possibilities (Section 2). We then look at early LFG analyses which treated morphology incrementally (Section 3). Then we review work on the syntax–morphology interface in LFG (Section 4). This sets the stage for a look at current approaches to morphology in LFG, which are realizational (Section 5). We will not have anything to say about the interactions of morphology, syntax, and prosody in LFG, because that is covered by another chapter in this volume, Bögel forthcoming [this volume].

2 Morphological theory and terminology

The landscape of morphological theory is defined by many key 'decision points' that we summarize here for subsequent use. These decision points are pretheoretically distinct from each other, but they have a tendency to cluster together in ways that will be reflected in morphological theories interfacing with LFG. We attempt to be neutral for each decision point, and also as brief as possible. We leave the detailed description of these distinctions to sources like Hockett (1954), Beard (1995), and Stump (2001), but also textbooks like Haspelmath & Sims (2010), which does an especially good job of describing these decisions.

2.1 Morphemes vs. words

The first of these is also the most basic. What are the 'atoms' of morphological theory? What are the inputs to morphological rules? What are the elements that morphology manipulates? Morphological theories fall into two basic classes:

those that subscribe to the *morpheme hypothesis* and those that do not. The former are typically called *morpheme-based* theories (or *morphemic* theories). The latter are typically called *word-based* theories (or *lexemic* theories).

In morpheme-based models, the inputs to morphological operations are idealized as one-to-one pairings of sound and meaning called *morphemes*. Later morpheme-based models, such as Distributed Morphology (Halle & Marantz 1993), have redefined "morpheme" to mean "abstract morphological feature". In these models, the sound-meaning pairing is better considered a *listeme* (Di Sciullo & Williams 1987) but is often called a *vocabulary item*. Historically, a 'word' is the morphological domain above morphemes. In most contemporary models of this kind, the 'word' is mostly epiphenomenal or refers to an extra-morphological domain (typically prosodic/phonological). In this context, a so-called 'simplex word' is nothing more than a domain containing only a single morpheme, while a so-called 'complex word' is a domain containing more than one morpheme.

In word-based models (Aronoff 1976), words are the atoms of the grammar. Morphological operations have words as their input and words as their outputs. In contemporary instantiations of word-based models, the *input* and *output* are not really the appropriate terms. Rather, 'words' have both abstract representations and phonological representations. The abstract form of a word is called a *lexeme*.[1] A lexeme is the basic representation of a word (often analogized to a dictionary entry). A lexeme may be derived from another lexeme via derivational morphology or compounding (and thus can be complex) but is never inflected. The phonological form of a word, which is fully inflected, is called a *word-form*, which can be conceptualized as a particular, (grammatically) context-sensitive, instantiation of a word. The word-forms of a lexeme are typically organized into paradigms.

There are many reasons why a theory might choose to assume words or morphemes — more than we could possibly summarize in this space. We posit the following as an oversimplified summary. The basic tendency observed in the crosslinguistic state of affairs is that morphology is affixal and morpheme boundaries are clearly identifiable. This is tautologically true in isolating and agglutinative languages, but even fusional languages, which almost always have *portmanteau* (many-to-one) morphemes, tend to have clear morpheme boundaries. On the other hand, divergences from this tendency are legion and likely exist in

[1]Word-based and lexeme-based models are not strictly the same (Aronoff 1994: 7). For example, not all word-based models assume lexemes, and some lexeme-based models are actually not word-based in the strict sense (lexemes are taken to be atoms of morphological descriptions, but words are not). For the purposes of this overview this simplification suffices. We thank an anonymous reviewer for helping us sharpen this point.

every language. *Templatic* (or root-and-pattern) morphology, such as found in Semitic languages, is not easily accounted for as affixation. *Stem allomorphy* and *suppletion*, especially in high frequency words, often involves a morphological alternation without clear morpheme boundaries. Furthermore, complex words frequently have lexicalized meaning, i.e. non-compositional meaning that is more than the sum of the contained meanings. These exceptional data are usually given exceptional explanations, such as diachronic ones. Put simply: the morpheme hypothesis captures the basic concatenative cross-linguistic tendency of morphology, but lacks synchronic empirical coverage of seemingly exceptional data. The word hypothesis is its opposite, capturing all the data, but needing to attribute the basic concatenative tendency to something else, such as diachronic pressures like grammaticalization.

2.2 Arrangement vs. Process vs. Paradigm

The second decision point is the type of rules that operate on the atoms. This distinction is originally described by Hockett (1954) as the contrast between *item-and-arrangement* (IA), *item-and-process* (IP), and *word-and-paradigm* (WP) models. The names for these models reflect their workings. In an IA model, morphology is simply the set of morphemes in a word and the arrangement of those morphemes. Thus, the arrangement itself (which is essentially simple concatenation) is the only 'morphological process'. In an IP model, rules (such as *affixation*, *reduplication*, *juxtaposition*, *suppletion*, etc.) are applied to a *base* (or *stem*), which may be complex or simplex, to generate a new complex form. IP models are compatible with both morphemes or words being the 'base'. Finally, WP models assume the morphology is the process through which all the word-forms in a word's paradigm are inferable from each other via some mechanism that generates a paradigm.

The reasons for adopting any of these three are similar to the reasons in Section 2.1. IA models have two strengths. Firstly, they capture the basic cross-linguistic generalization: the vast majority of morphology can be explained with simple concatenation. Secondly, many practitioners of IA models find such a simple operation to have an elegance and restriction that are laudable metatheoretical goals. Because of this, IA would be preferred by those theorists for whom such theoretical elegance is a high-ranking concern. Again, we find that such practitioners are satisfied that putatively non-concatenative processes have potential diachronic explanations.

There are familiar reasons to assume IP models, which again, as in Section 2.1 appear to be the opposing reasons. Chief among them is that IA models under-describe the data. IA models end up accounting for everything with affixation, including apparently non-affixal morphology like *functional shift*, *back-formation*, *stem allomorphy*, *suppletion*, *stress shift*, *truncation*, and *reduplication*. Affixal explanations for these phenomena tend to be fairly stipulative and lead to a proliferation of null morphemes that condition these changes (which are themselves a violation of theoretical parsimony, despite this concern being a primary motivation of such approaches). IP practitioners point out that there is also a ready-made counter-explanation from diachrony for the prevalence of concatenation: the chief source of morphology is grammaticalization, which (ultimately) leads to affixes. Furthermore, although rule-based morphological models are undoubtedly much more powerful than IA models, that power comes with significant empirical coverage, which is arguably worth the trade-off. In many varieties of both WP and IP models, in the idealized case, any two word-forms can be mutually predictive. This allows rules to apply 'backwards', capturing phenomena such as *backformation* or *cross-formation* (see, e.g., Becker 1993). These types of morphological alternations are difficult to capture in an IA model.

The appeal of WP models over the other two is the ability to make reference to the paradigm as an abstract entity. In the domain of inflection, many generalizations, especially *morphomic* ones, can be captured by referring to the paradigm itself. A *morphome*, as described in Aronoff (1994) and Luís & Bermúdez-Otero (2016), among others, is a purely morphological pattern. The existences of morphomes is controversial (a debate captured well in Luís & Bermúdez-Otero 2016). The most salient of proposed morphomes in this debate are root allomorphy patterns like the 'L pattern' and the 'N pattern' (see Maiden 2018), which are literally described as patterns in a paradigm (e.g., cells arranged in an L or an N). Thus WP models are uniquely well-situated to account for these. On the other hand, arrangement accounts usually deny the existence of morphomes as paradigm effects and instead account for them via some other mechanism (see Trommer 2016).

Similarly, patterns of syncretism lend themselves to paradigmatic explanations. Paradigmatic explanations are especially well suited to highly fusional languages as are common in Indo-European. They also lend themselves easily to complex agreement patterns that are cross-linguistically ubiquitous. Furthermore, because a paradigm cell can contain multiple forms or even no forms, WP models allow explanations for both *optionality* and *defectiveness*/*ineffability*. The tradeoff here is paradoxical: on the one hand, paradigmatic models tend to have little to say about derivation[2] and compounding, so they under-describe the data;

[2]There are some notable exceptions, though, such as Booij (2010) and Spencer (2013).

on the other hand, paradigms are much more powerful than needed for most of the world's languages, so in another respect, they over-describe the data.[3]

2.3 What is the lexicon?

The third decision point is the nature of the word-storage component of the grammar. For example: Is the lexicon a productive component of the grammar or simply a passive list of memorized forms? While the terminology here is far from consistent in the literature, for the purposes of this chapter we will use *lexicon* to denote a generative/productive component of the grammar responsible for word-formation. We will use *vocabulary* for a passive component which is simply a list of memorized items. There is nothing inherently contradictory about a model having both a lexicon and a vocabulary. It just happens that most models with a productive component typically assume that that component is also the one responsible for word-storage. Indeed, this dual role is central to many models of *blocking*, such as the original one developed by Aronoff (1976). On the other hand, Di Sciullo & Williams (1987) argue for both a lexicon and a vocabulary (without using those terms).

There are some downstream effects of the decision to have a component dedicated to word-formation. If it is assumed that the lexicon is productive, a decision must be made on how much it is responsible for. The *Single Component Hypothesis* claims that all three distinct types of morphology (derivation, inflection, and compounding) are handled by the same generative component. On the other hand, the *Split Morphology Hypothesis* claims that derivation and inflection are handled by separate components. Thus, it is not uncommon to have two distinct word-formation components, one for derivation and one for inflection, depending on a particular model's definition of *lexeme*. This is made explicit in the WP model of Anderson (1982, 1992), where the paradigms are only responsible for inflection.[4]

Provided you assume that morphology is not its own domain, there seem to be two obvious non-morphological components involved in ordering morphological elements. One of these is prosody/phonology, as seen in models such as Optimality Theory (Prince & Smolensky 2004). The other, more common, account for ordering morphological elements outside of a lexicon is the syntactic

[3]Word and Paradigm models encompass more than just what is described here, including adaptive discriminative models such as Blevins et al. (2016), but these have not yet been meaningfully interfaced with LFG, so we set them aside here.

[4]Split morphology theories are properly ambivalent about the place of compounding; we do not address compounding in this chapter.

component. The *Morphosyntax Hypothesis* — this is not its common name but will suit our purposes — assumes that all of morphology and syntax are handled by the same component of the grammar. This entails the strong claim that autonomous morphological phenomena do not exist, and are instead attributable to the morphological interfaces with phonology and syntax. The *Weak Lexicalist Hypothesis* separates derivation from inflection: Derivation is handled by a lexicon while inflection is part of the syntactic structure. By contrast, the *Strong Lexicalist Hypothesis* is the name for a model where all of word-formation is Lexical/non-syntactic.

We won't get into the reasons why a syntax model might adopt variations on the Lexicalist Hypothesis. We leave that to elsewhere in this handbook. From the point of view of morphological theory, there are distinct reasons to consider breaking the class of things called 'word-formation' into distinct components. Data on morphological structure suggests compounding and derivation are of a kind that is distinct from inflection. In the domain of derivation and compounding, fully productive morpheme ordering overwhelmingly generalizes as *headed hierarchical structure* (the type of structure usually represented by trees in syntactic theory). In inflection, on the other hand, to the extent that morpheme boundaries are even identifiable, they tend to be arranged in ordered flat structure (i.e., a *list*). Constituency tests that show hierarchical structure tend to fail, despite strict ordering. Alternatively, when boundaries are less identifiable, the morphology appears to be arranged *paradigmatically*. This difference is mostly captured by the distinction between an agglutinative and a fusional inflectional system. A key reason for treating inflection as different from other kinds of morphology is precisely because of the apparent structural distinction between a linear structure (inflection) and a hierarchical structure (derivation). Conversely, while inflection is overwhelmingly productive and expresses compositional meaning, derivation and compounding have a much greater (but still small) likelihood of having non-compositional meaning and being less than fully productive. This is yet another reason to partition morphology into distinct classes.

Finally, and perhaps most importantly, to the extent that we can today justify that derivation is a distinct empirical category from inflection, following Anderson (1982), the chief generally observed distinction (outside of the hierarchical/linear/paradigmatic ones above) is that inflection is relevant to the syntax. Inflection comes in two varieties. The first empirical category is those inflections that express grammatical configurations (*contextual inflection;* Booij 1996). For example, case and subject/object agreement on verbs express the relationship between verbs and their dependents. Similarly, nominal concord expresses the relationship between nouns and their dependents. Importantly, languages appear to have the option of expressing these relationships either via morphology or through a fixed word order (or both). The other empirical category of inflection is those morphological reflexes of so-called 'morphosyntactic' or 'morphosemantic' categories (*inherent inflection;* Booij 1996). These are such properties as tense, aspect, voice, mood, number, definiteness, etc. Again, languages appear to have the choice of expressing these properties morphologically or syntactically (through separate categories such as auxiliaries, clitics, prepositions, etc).

Given these differences, it makes sense to split a *lexicon* into two pieces: one that handles so-called *lexeme-formation* and another that handles inflection (but see Booij 1996 for counter-arguments). These two components can then have fundamentally different types of processes and can have different relationships with the syntactic component. And indeed, this division of labor is common in Word-and-Paradigm models today For a review of the history and state-of-the-art of WP models, see Blevins (2018).

Since syntax is also naturally represented, at least in part, by headed hierarchical structures, the parsimonious approach to grammar is to identify the extent to which all such structure can be done with the same component — in other words, to assume a single component that generates headed hierarchical structure, whether the structure represents 'syntax' or 'morphology'. Compounding and derivation can similarly easily be accommodated to a component that generates headed hierarchical structure, especially if we restrict the model to only the most productive processes and we are willing to assume that non-compositional morphological meaning is fundamentally the same as non-compositional idiomatic syntactic constructions. We would have to then be willing to postulate vacuous hierarchical structure in inflection, but this postulation is arguably worth the trade-off for overall parsimony. The call of parsimony is heightened by the definitional interdependence of syntax and inflection. In fact, an Item-and-Arrangement model has already made certain empirical sacrifices for parsimony and restriction goals. It seems that no further sacrifices are needed to assume a single morphosyntactic component. The gain in parsimony is even further support for Item-and-Arrangement from this point of view, so it is not surprising that most models today that assume an Item-and-Arrangement model reject the Lexicalist Hypothesis and adopt a passive *vocabulary*. But deciding to approach morphology by reducing it to syntactic (and/or phonological) operations is not restricted to Item-and-Arrangement approaches. Similarly, *construction-based* approaches to morphology (Booij 2010, Masini & Audring 2018) generally assume that the *construction* is both a morphological and syntactic mechanism. This property of having a shared mechanism is often summarized as 'X all the way down', where X is *constructions* in construction-based approaches, *syntax* in standard Distributed Morphology, and *constraints* in Lexical-Realizational Functional Grammar.

Approaching morphology via a single morphosyntactic component has significant empirical justifications as well. There are several commonplace phenomena that blur the lines between word and phrase, suggesting that distinction is more one of convenience than a justifiable categorical contrast. Such phenomena include for example: clitics, phrasal affixes, phrasal compounds, valance changing devices, separable prefixes (of the Germanic variety; e.g., Booij 2002), object incorporation (of the Mohawk variety; e.g., Baker 1988). Because these phenomena appear to be both syntactic and morphological, it is appealing to these practitioners to find unitary explanations, which ultimately rest on not positing a syntax/morphology distinction.

2.4 Lexical vs. inferential

While not strictly distinct from our classification above, it is worth taking a moment to describe a distinction that is common in the literature, especially within models that interface with LFG. Stump's (2001) typology of morphological theories of inflection includes a distinction between two types of theory: *Lexical* and *Inferential*. In a lexical model, the lexicon (or vocabulary) stores associations of inflectional properties and phonological properties. A complex word is an ordered set of these associations. Conversely, in an inferential model, the systematic associations are between a lexeme and its word-forms. Word-forms are inferred from their stems by rules (not restricted to concatenation) that associate aspects of form with aspects of grammatical content. In sum, lexical models are concerned with listed lexical objects (words or morphemes), whereas inferential are concerned with rules.

In the typology that we are describing here, these distinctions are not basic. Instead, they are composites of the distinctions above. While it may not be the case that Stump (2001) intends "lexical" to comprise these four properties, the examples of *lexical* models that Stump (2001) lists all share in common that they are *morpheme-based*, *Item-and-Arrangement*, and *morphosyntactic* with a passive *vocabulary*. In contrast, an *inferential* model is *word-based*, and assumes *Strong Lexicalism* (at least for inflection, which is what Stump 2001 is concerned with).

2.5 Incremental vs. realizational

The final distinction that we describe here concerns the relationship between information and morphology. In an incremental model, morphology is *information-*

adding. That is, a word gains grammatical complexity (i.e., morphosyntactic properties) at the same time, or as a function of, gaining complex morphology. For example, on this conception, adding the plural morpheme to the word is what makes it plural. In opposition to this stand *realizational* models. In a realizational model, morphology is *information-expressing*. Some aspect of grammar that is external to the morphology supplies a set of morphosyntactic properties (which may or may not include a *root*). What we conceptualize as morphology then expresses that set of morphosyntactic features. Depending on other choices made, this expression might be a passive mapping to phonology or the application of a realizational rule. In these models, morphology provides the *exponence* of morphological properties (the *exponenda*).

This distinction is not so much an active distinction today since most contemporary morphologists assume *some* variety of realizational morphology. This can be achieved via paradigms (Paradigm Function Morphology; Stump 2001, 2016, Spencer 2013), morpheme-insertion (Distributed Morphology; Halle & Marantz 1993), or constructions (Construction Morphology; Booij 2010, Masini & Audring 2018; Optimal Construction Morphology; Inkelas et al. 2006, Caballero & Inkelas 2013, Inkelas 2016). The simple reason for this is that morphology, especially inflection, both under- and overdetermines its featural content.

The underdetermination part has always been well-known. For example, a fundamental property of inflection and primary explanandum of morphological theory is the fact that the morphosyntactic features overtly expressed by an inflected form are often a subset of those properties that are associated with the word. For example, it is common for gender to be unexpressed in combination with participant persons (1^{st} and 2^{nd}). Similarly, it is also common for person features to be unexpressed in combination with past tense or plural number (see, for example, Bjorkman et al. 2021).

Interestingly, the reverse is true as well, which demonstrates the case of overdetermination. Morphosyntactic properties are often expressed *multiply* without additive meanings; this is usually called *multiple exponence*. For example, *children* is not 'multiply plural' despite having three distinct reflexes of plural (vowel change, historic *-r* plural, historic *-en* plural). What is noteworthy here is that the multiple expression of plurality is *grammatical*. One wouldn't expect this of an iterated plural function, which is what multiple applications of a plural morpheme might lead one to expect (see, for example, Harris 2016).

3 Incremental morphology and LFG

3.1 Phrase structure rules as word-formation rules

An obvious approach to concatenative morphology is to capture morphological well-formedness using similar (annotated) phrase structure rules to the ones that license c-structures (Selkirk 1982). The difference is that the morphological ones use morphological categories. However, standard LFG assumes *Strong Lexicalism*, so it is important to note that this is happening in different combinatorial components of the grammar – morphology versus syntax. Pedagogical presentations such as Bresnan et al. (2016), out of necessity simplify representations in such a way that this important distinction is masked. In the problem set on West Greenlandic (Bresnan et al. 2016: 364–369), we find the example in (1) below, analyzed with the assistance of the morphological rule in (2), and the sketch of an analysis for (1) in (3).[5]

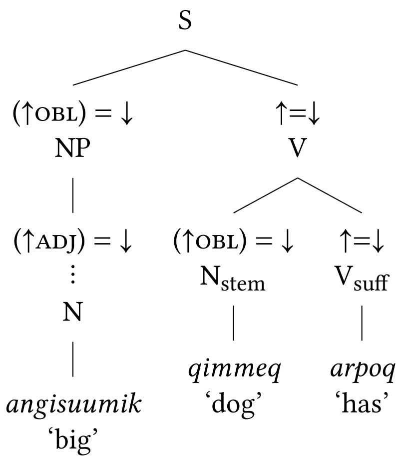
(1) West Greenlandic
Angisuu-mik qimmeq-arpoq.
big-INS dog-have.IND.3.SG
'He has a big dog.'

(2) $$\mathrm{V} \longrightarrow \underset{(\uparrow \textsc{obl}) = \downarrow}{\mathrm{N}_{\mathrm{stem}}} \quad \underset{\uparrow = \downarrow}{\mathrm{V}_{\mathrm{suff}}}$$

Note that this rule looks just like a c-structure rule, except with a c-structure category on the lefthand side of the rule and morphological categories on the righthand side. In other words, it is the *outputs* of these morphological rules that form the *inputs* to the c-structure rules.

[5]We have left the morphological glosses off the free English translation in (3), which is not present in Bresnan et al. (2016: 446); this is just a rough approximation of the glossing in (1). We have also elided some annotations from the original.

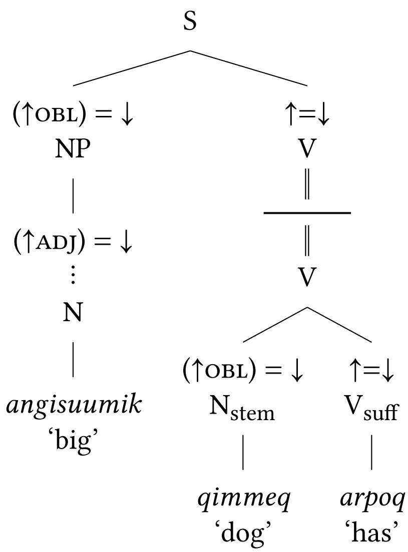
(3)



However, notice that the node labelled V in this tree is actually licensed by the *morphological* rule in (2). In another sense, this very same V is also licensed by the c-structure rule for S, which is easily inferable from (3).

However, if morphology and syntax are distinct grammatical modules, per Strong Lexicalism, then it can't actually be a single rule set that captures both aspects of V, as implied by (3), even if the mechanisms involved are the very same for both syntax and morphology (annotated phrase structure rules) in this incremental approach to LFG morphology. Thus, a more transparent way to represent (3) may be something like the following (following Ishikawa 1985: 285):

(4)



The horizontal line represents the syntax/morphology 'boundary' and we see that V has a foot on each side. This representation is arguably more transparent about the full set of theoretical claims behind (3). But it also highlights that the licensing mechanisms for c-structure and morphology are redundant in this sort of incremental morphology for LFG.

It is important to realize, though, that in early LFG, incremental morphology through phrase structure rules was not merely a pedagogical simplification. There were proposals in early LFG research on morphologically rich languages that involved phrase structural incremental morphology, such as Baker (1983), Ishikawa (1985: ch. 3)[6] and Nordlinger (1997, 1998). For example, Nordlinger (1997: 107) proposes the following morphological rule for case affixation in various dependent-marking languages of Australia (including, e.g., Kayardild, Martuthunira, Thalanyji, Wambaya):

(5) $\mathrm{N} \longrightarrow \underset{\uparrow=\downarrow}{\mathrm{N}} \quad \underset{\uparrow=\downarrow}{\mathrm{Aff}}$

Nordlinger subsequently revised this incremental analysis in favour of a realizational approach (Sadler & Nordlinger 2004, 2006), which will be discussed further in Section 5.1.

In sum, the early incremental approach to morphology that was commonly assumed by LFG was a straightforward, even traditional, *morpheme-based*, *item-and-arrangement* approach.

3.2 Finite-state morphology

Another question that arises with incremental phrase-structural morphology is one of computational complexity/power. One way of expressing the intuition that morphology is generally concatenative is to observe that regular languages/ finite state automata, which are the Type 3 grammars in the Chomsky Hierarchy (Chomsky 1957, 1965, Partee et al. 1990: part E), are computationally sufficient for generating concatenative morphology. One can make an even stronger claim, which is that almost all of morphology requires no more than finite-state power, except for total reduplication (Beesley & Karttunen 2003, Roark & Sproat 2007: 25, 53–60), which is beyond finite-state power, since it requires exactly matching a preceding string of unlimited length.[7]

[6] See Bresnan et al. (2016: 396) for a simplified presentation of some of Ishikawa's proposals.

[7] Note that Beesley & Karttunen (2003) build their system around the operation of *concatenation*, whereas Roark & Sproat (2007) argue that the operation of *composition* is more general and is to be preferred. Among other considerations, *composition* gives a more natural finite-state solution to templatic (root-and-pattern) morphology (Kiraz 2001, Roark & Sproat 2007: 41–44).

Let's now turn back to the particular kinds of proposals for phrase-structural morphology that we saw in Section 3.1. The computational power of phrase-structural morphology is at least context-free, which is more powerful than required and corresponds to a higher level in the hierarchy. In other words, representing concatenative morphology in a phrase structure format gives the morphological component more potential power than seems justified by linguistic data. Moreover, once we add f-structure annotations to morphological phrase structure rules, we are potentially in the yet more powerful class of mildly context-sensitive languages (Joshi et al. 1991), since we would have the full power of LFG. This seems too powerful.

For example, if morphology were mildly context-sensitive, we might expect to see *morphological* long-distance dependencies or cross-serial dependencies, but we are not aware of any morphological phenomena that straightforwardly demand such analyses. It might seem that phenomena such as circumfixion or vowel harmony are candidates for morphological long-distance dependencies, but these can in fact be handled by finite-state means (Beesley & Karttunen 2003). Some agreement phenomena, like the Ojibwe PERSON discontinuity in (35) below, might similarly seem long-distance, but are in fact clause-bounded, so we expect that FSM could handle them. We are aware of so-called 'long-distance agreement' (Butt 1993, Bhatt 2005), but we are not aware of any such case for which there is no viable non-long-distance solution. Lastly, it might seem that templatic morphology shows a morphological need for an indexed language (mildly context-sensitive) to line up consonants and vowels properly. However, it has been shown that a composition-based finite-state approach can indeed handle templatic morphology (Kiraz 2001, Roark & Sproat 2007).

It should be noted that actual computational work on LFG, in the context of the Parallel Grammars (ParGram) project (Butt et al. 1999; Forst & King forthcoming [this volume]), uses finite-state morphology, rather than incremental phrase-structure morphology. Indonesian is among the languages in the ParGram project and does have productive total reduplication. The ParGram Indonesian grammar only allows for reduplication of words already in the dictionary/lexicon. This means that the FSM can extract the morphological feature encoded by the reduplication (because there is a finite vocabulary). However, on encountering a word for the first time, such a system cannot recognize the reduplication and so cannot extract the morphological feature encoded.[8] Thus, the full productivity of Indonesian reduplication is not modelled in the ParGram grammar.

In sum, the FSM approach is a restrictive approach that also yields broad

[8]We thank Ron Kaplan (p.c.) for discussion of this point. Any remaining errors are our own.

coverage of morphological phenomena; for example, see the many case studies in Roark & Sproat (2007). The restrictiveness of the FSM approach makes it very attractive, even more so when coupled with the fact that FSM approaches have revolutionized applications that require morphological analysis, such as spell-checkers, part-of-speech taggers, and speech recognition and production systems (Kaplan & Kay 1994, Beesley & Karttunen 2003, Roark & Sproat 2007). Nevertheless, this does not mean that we should conflate theories with their formal or computational bases. Using an analogy from syntax, the mildly context-sensitive formalisms of Lexicalized Tree-Adjoining Grammar, Categorial Grammar, and LFG form a computational equivalence class but nevertheless underpin distinct theories. As Roark & Sproat (2007) themselves emphasize, theoretical distinctions may matter even if the options are computationally equivalent. For example, they consider Tagalog *-um-* infixation, as in *tawag* ('call') versus *tumawag* ('call (perfective)'). They note that it is computationally "immaterial" from an FSM perspective whether we conceive of the infix as attaching to *t-* or to *-awag* (Roark & Sproat 2007: 30–31). However, from a theoretical perspective, these two solutions are clearly not equivalent. In particular, Tagalog *um* is an infix in consonant-initial words (with some exceptions, where it cannot appear at all), but is a *prefix* in vowel-initial words, such as *abot*, which becomes *umabot* ('to reach for') (Orgun & Sprouse 1999: 204). On theoretical grounds, it therefore seems preferable to think of *um* as attaching to the element to its right, as McCarthy & Prince (1993) and Orgun & Sprouse (1999) conclude, but to FSM the two options (dependency on the preceding or following element) are equivalent and the distinction immaterial.

3.3 Lexical rules

Throughout the early history of LFG, theorists made crucial use of *lexical rules*, such as found in Bresnan (1982). These lexical rules were almost always employed to capture argument structure alternations, like passivization. Another way to think about the effect of lexical rules is that they concern the remapping of grammatical functions. These rules frequently had morphological reflexes in addition to their argument-structure-changing properties, but they also frequently did not (see the example lexical rules for gerundives in Bresnan et al. 2016: 316–317). In fairness, these rules were not normally postulated from the point of view of morphological theory, so the emphasis was not on their morphological reflexes or how to use them to capture morphological generalizations. Moreover, lexical rules were not systematically codified into a model that we could discuss explicitly here.

Nevertheless, it was clear that these rules are explicitly non-syntactic. For example, in Falk's textbook they are described thus (Falk 2001: 93):

> [A] lexical rule of this kind is not monotonic: it takes existing information and changes it. This is ruled out in principle in the syntax on grounds of processing: syntactic information cannot be changed. But a lexical rule is not a syntactic rule. Lexical rules do not represent on-line processing, but rather regularities relating stored lexical items. When a lexical rule is applied productively, the result is stored as a new lexical item. For this reason, the usual LFG constraint against changing information is inapplicable here.

Falk's pedagogical point is revealing of an important foundational tenet of LFG: syntax is monotonic, so no non-monotonicity can be syntactic. It therefore follows that argument alternations are non-syntactic, since they are non-monotonic. In other words, allowing the lexical rules to behave non-monotonically shields the syntax.

On the other hand, Baker (1985) explicitly considers lexical rules from the point of view of morphological theory, arguing precisely that because GF-rules (argument structure rules) and word-formation rules align on the same element in LFG (i.e., the lexical rule as developed in Bresnan 1982), LFG was especially well equipped to capture the "lexicalist approach" to the Mirror Principle (Baker 1985: 409). To the extent that these lexical rules were codifiable in the categories we have laid out, these rules often generated affixation as in the types described by Baker (1985), but most frequently required the power and mechanisms of an *Item-and-Process* approach to morphology, especially because they were often expressed with non-concatenative (frequently null) morphology and were explicitly both information-adding and information-destroying, the latter of which cannot be done with concatenation alone.

4 The syntax–morphology interface

Some work on morphologically conditioned syntactic order (e.g., restrictions on verbal sequences, as found in English 'affix hopping'; Chomsky 1957) has proposed a structure called m(orphological)-structure to shield f-structure from features that are morphological in nature (Butt et al. 1996, Frank & Zaenen 2002). This unfortunately gives the impression that m-structure is the morphological component of LFG, but this is not really the case, as we'll see in Section 4.2. First, though, we turn to a general framework for the interface between an LFG syntax and a realizational morphology (Dalrymple 2015). This better sets the context for the discussion of m-structure.

4.1 A general framework

Dalrymple (2015) presented a new, systematic approach to realizational morphology for LFG (see also Dalrymple et al. 2019: ch. 12). It is clear, though, that the morphological output is intended to be something similar or identical to Paradigm Function Morphology (Stump 2001, 2016). We return to that aspect of the Dalrymple analysis in Section 5.1, where we discuss it along with other approaches to a PFM interface with LFG (Ackerman & Stump 2004, Sadler & Nordlinger 2004, Spencer 2013, Thomas 2021).

Dalrymple (2015) assumes, following Dalrymple & Mycock (2011), Mycock & Lowe (2013), that the traditional lexical phonological string is comprised of two aspects, the *s-string* which interfaces with c-structure via the π correspondence function and the *p-string* which interfaces with prosodic structure (via the β correspondence function; Dalrymple et al. 2019: 409). This is illustrated explicitly in Figure 1.

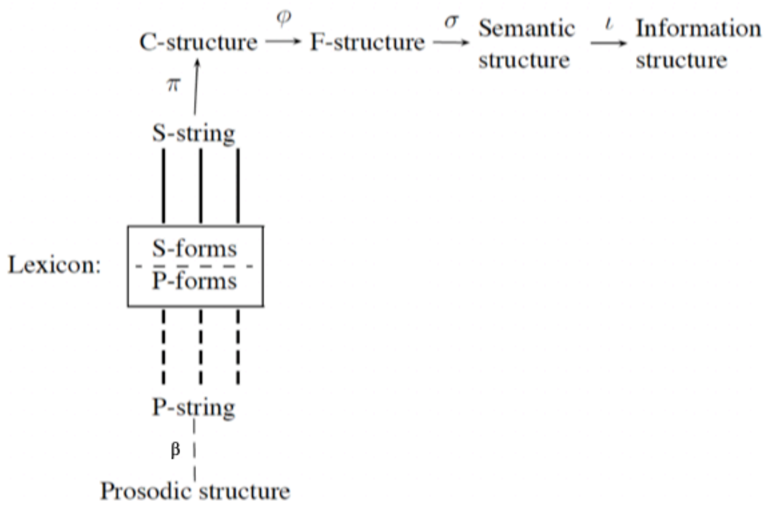


Figure 1: Proposed LFG Correspondence Architecture. From Dalrymple & Mycock (2011: 178, (5); see also Dalrymple et al. 2019: 409); used with permission.

A sample lexical entry for *dogs* from Dalrymple (2015: 67, (3)) is shown here:[9]

[9]This simplified lexical entry sets information structure aside; see Dalrymple (2015: 66).

(6)

s-form	($\bullet$ FM) = dogs
c-structure category	$\lambda(\pi(\bullet))$ = N
f-description	($\uparrow$PRED) = DOG ($\uparrow$NUM) = PL
p-form	/dɔgz/

It is convenient to represent the information in lexical entries as a relation (Dalrymple 2015: 67 (4)):

(7) $\mathcal{L}$⟨s-form, p-form, category, f-description⟩

The particular information in (6) can therefore compactly be represented as (Dalrymple 2015: 67 (5)):

(8) $\mathcal{L}$⟨dogs, /dɔgz/, N, {($\uparrow$PRED) = DOG, ($\uparrow$NUM) = PL}⟩

This lexical entry generates the structures and correspondences in Figure 2.

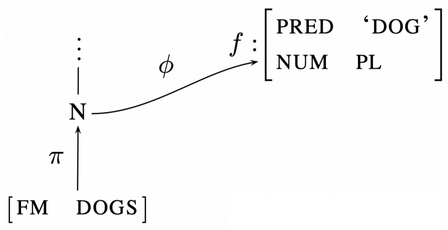


Figure 2: *Dogs*, contributions to the s-string, c-structure, and f-structure. Adapted from Dalrymple (2015: 66, (2)); used with permission.

Dalrymple (2015: 68) assumes, following Spencer (2013), that a *lexemic entry* consists of information about the form of the root (and any non-predictable alternations), any syntactic information and requirements, a representation of the semantics of the lexeme, and an arbitrary unique lexemic index. Dalrymple (2015: 68, (7)) therefore defines a lexemic entry as follows:

(9) *Lexemic entry*
⟨root & idiosyncratic stem forms, f-description, lexemic index⟩

She gives the following particular examples (Dalrymple 2015: 68 (8–9)):

(10) a. ⟨{ROOT: dog}, { ($\uparrow$PRED) = DOG }, DOG1⟩

b. ⟨{ROOT: child; STEM1: children}, { ($\uparrow$PRED) = CHILD }, CHILD1⟩

The question is how these lexemic entries interact with the morphological component to produce complete lexical entries. For example, how does the lexemic entry for DOG1 produce the lexical entry (8)?

The answer is illustrated in the diagram in Figure 3. The realization of the s-string form (*s-form*) and the p-string form (*p-form*) are handled by the morphological realization function, *R*, which also contributes morphological features (*m-feats*) based on the ID of the lexemic entry (LI). The morphosyntactic description function, *D*, uses the m-feats to represent the syntactic category and morphologically contributed f-description. The final lexical entry has the s-form and p-form that are computed by the realization function *R* (based on the m-feats), the syntactic category that is computed by the description function *D* (again based on the m-feats), and the f-description that is the union of the lexically contributed f-description from *LE* and the morphologically contributed f-description from *D*.

The relations between the different elements can be illustrated in a logic-programming-style representation, as in Figure 4. This representation reveals some redundancy. In particular, it's not clear why *R* and *D* each need access to both the lexemic index (LI) and the set of m-features (M), especially given that M must be computed based on LI. A more streamlined representation would eliminate LI from *D*. It would certainly be theoretically elegant if the set of m-features was sufficient to determine the category C and the morphologically contributed f-description G. However, there are empirical cases that show that *D* must be directly conditioned on LI, such as the syntactically singular but morphologically plural *measles* (Dalrymple 2015: 75).

As we mentioned above, Dalrymple's (2015) model is not a theory of morphology, but rather a theory of the interface between syntax and morphology. Nevertheless, it is most compatible with a morphological theory that is *lexemic*, is *Word-and-Paradigm*, and assumes *Strong Lexicalism.*

4.2 M-structure

As noted above, Dalrymple (2015) sees her framework as a general framework for realizational morphology and it is a feature of the approach that it is very much backwards-compatible with existing LFG proposals about morphological conditioning of syntax, such as the proposals for adding a m(orphological)-structure to the Correspondence Architecture by Butt et al. (1996) and Frank & Zaenen (2002), which are both LFG accounts of affix ordering restrictions (e.g., English 'affix hopping'). The main distinction between the two proposals is that the first holds that m-structure is projected from c-structure (Butt et al. 1996), whereas

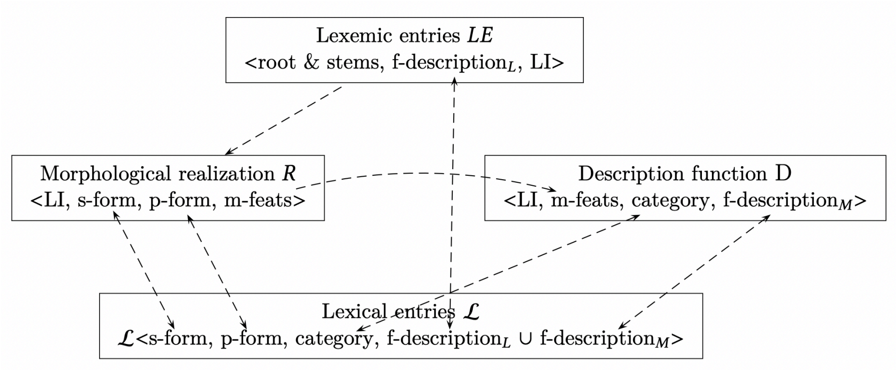


Figure 3: How the set of lexical entries, $\mathcal{L}$, is computed from the set of lexemic entries, *LE*, using a morphological realization function, *R*, and a description function, *D* (Dalrymple 2015: 70 (15); used with permission)

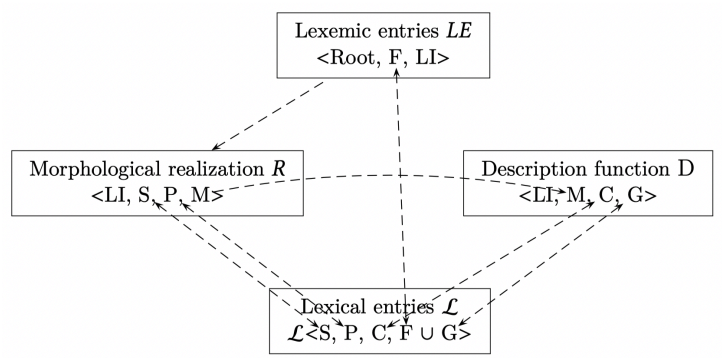


Figure 4: Logic-programming-style representation of the relations between $\mathcal{L}$, *LE*, *R*, and *D*

the second holds that m-structure is projected from f-structure (Frank & Zaenen 2002).

The *morphological entry* (m-entry), i.e. instance of *R*, based on Butt et al. for *swimming* is shown here:

(11) $R\langle$swim1, swimming, /swɪmɪŋ/, {m-cat:verb, m-vform:prespart}$\rangle$

The relevant *D* mapping would then be:

(12) m-vform:prespart $\overset{D}{\Rightarrow}$ {($\hat{*}_\mu$ vform) = prespart, (↑aspect) = prog)}

Given the same m-entry in (11), the relevant *D* mapping based on Frank & Zaenen would instead be:

(13) $\text{M-VFORM:PRESPART} \overset{D}{\Rightarrow} \{(\phi(\hat{*})_\mu\ \text{VFORM}) = \text{PRESPART}, (\uparrow\text{ASPECT}) = \text{PROG})\}$

We have represented things this way for maximum comparability with (12), but $\phi(\hat{*})$ is just $\uparrow$, so we could have written $\uparrow_\mu$ instead:

(14) $\text{M-VFORM:PRESPART} \overset{D}{\Rightarrow} \{(\uparrow_\mu\ \text{VFORM}) = \text{PRESPART}, (\uparrow\text{ASPECT}) = \text{PROG})\}$

Note that there are other differences between the Butt et al. theory and the Frank & Zaenen theory, but we've kept things as simple as possible for direct comparison. See Dalrymple (2015) for further details regarding both of these approaches to m-structure. It's important to realize, though, that m-structure concerns morphological conditioning on syntactic order and is not a theory of morphology per se. However, we have seen that the Dalrymple (2015) framework, which *can* provide the foundation for a theory of morphology, accommodates both approaches. This demonstrates the Dalrymple framework's generality. M-structure is most compatible with a morphological theory that is *lexemic*, is *Word-and-Paradigm*, and assumes *Strong Lexicalism*.

5 Realizational morphology and LFG

As noted in Section 2.5, realizational morphology is done today in three major ways:

1. The word-based approach, such as Paradigm Function Morphology (Stump 2001, 2016, Spencer 2013).

2. The morpheme-based approach, such as Distributed Morphology (Halle & Marantz 1993) and Nanosyntax (Starke 2009, Caha 2009)

3. The construction-based approach, such as Construction Morphology (Booij 2010) or Optimal Construction Morphology (Caballero 2008)

To our knowledge, neither Construction Morphology nor Optimal Construction Morphology has been interfaced with LFG, so we set them aside here. We focus in particular on PFM and DM interfaces to LFG. PFM and LFG have a history going back at least to Sadler & Spencer (2004). There has also been renewed interest in PFM+LFG (Dalrymple 2015, Dalrymple et al. 2019), as well as recent interest in DM+LFG (Melchin et al. 2020, Asudeh et al. 2021, Everdell et al. 2021, Asudeh & Siddiqi 2022).

5.1 LFG interfaced with PFM

The first attempts to interface LFG with Paradigm Function Morphology (Stump 2001, 2016, Spencer 2013) were undertaken by Sadler & Nordlinger (2004, 2006) to account for highly complex case-stacking in certain Australian languages and by Ackerman & Stump (2004) to deal with the general problem of *periphrasis*. However, the complexity of the data and phenomena involved precluded either of these collaborations from simultaneously providing a general theory of realizational morphology for LFG. As we have seen, steps in that direction were taken by Dalrymple (2015) and Dalrymple et al. (2019). Although the Dalrymple framework is general and not specifically geared towards PFM, there is a deep compatibility between LFG's version of Strong Lexicalism, the Lexical Integrity Principle (see (38) below), and PFM. As Dalrymple (2015) presumably wishes to preserve Lexical Integrity/Strong Lexicalism — the traditional/default stance in LFG theory — then it is natural that she envisages a word-based morphology. Thomas (2021: 22) aptly sums up this underlying compatibility as follows:

> Unlike many other theories of morphology, the concept of a 'morpheme' is irrelevant to PFM: there is no conception of a form-meaning pair below the level of the word, as only fully inflected forms are associated with morphosyntactic property sets. This aligns with the Lexical Integrity Principle of LFG, by which terminal nodes must correspond to fully inflected words, rather than to morphemes or other sub-word elements.

If one wishes to retain LFG's Strong Lexicalism, such that the fundamental building blocks of syntax are words, then it makes sense to interface the syntax with a word-based theory of morphology. And PFM is arguably the most formally well-developed realizational, word-based morphological theory, making it a natural choice. Indeed Thomas (2021: 23) notes in passing that PFM's rigorous formalization offers another natural point of compatibility between PFM and LFG: "PFM also shares with LFG a commitment to being formally explicit and rigorously testable, as well as computationally implementable."

PFM's fundamental claim is that lexemes are represented as pairs of a form and a set of morphological properties (captured as features). Thus, in $\langle \mathrm{X},\sigma \rangle$, X is the form and σ is the set of properties. A paradigm function relates the lexeme to its inflectional realizations, by mapping the input form to an output form given the morphological properties:

(15) $\langle \mathrm{X},\sigma \rangle \xrightarrow{f} \langle \mathrm{Y},\sigma \rangle$

These paradigm functions are defined in terms of realization rules, which consist of *rules of exponence* and *rules of referral*. Rules of exponence realize the property set directly. Rules of referral instead refer the realization of their property sets to one or more other realization rules. There is a limited number of additional rule types; furthermore Stump's (2001) notion of paradigm has been refined in Stump (2016), which is typically called PFM2. However, this simple account will have to serve our purposes.

The realization rules in PFM are arranged into ordered rule *blocks*; however, there is no ordering within blocks. Given Panini's principle, the effect of block ordering mimics concatenation, but allows a morphologically synthetic form (*portmanteau*[10]) to block a morphologically analytic form. Selection of the correct rule in any given block is governed by Paninian blocking: the most specific rule that can apply in any given rule block must apply. PFM also assumes a principle called the Identity Function Default (IFD), which states that the identity function is a member of every rule block: If no other rule applies, the output is identical to the input.

This is exemplified by the following rules for Swahili future and past tenses (Stewart & Stump 2007: 402–403), which Thomas (2021: 22) presents in simplified form.[11] We have adapted the representation for maximal consistency with (15) above.

(16)

Block A	⟨X,σ:{CAT:verb,TNS:fut}⟩	⟶	⟨*ta*X,σ⟩
	⟨X,σ:{CAT:verb,TNS:past}⟩	⟶	⟨*li*X,σ⟩
	⟨X,σ:{CAT:verb,POL:neg,TNS:past}⟩	⟶	⟨*ku*X,σ⟩
Block B	⟨X,σ:{CAT:verb,AGR(su):{PERS:1,NUM:sg}}⟩	⟶	⟨*ni*X,σ⟩
	⟨X,σ:{CAT:verb,AGR(su):{PERS:2,NUM:sg}}⟩	⟶	⟨*u*X,σ⟩
	⟨X,σ:{CAT:verb,AGR(su):{PERS:3,NUM:sg},GEN:{1,2}}⟩	⟶	⟨*a*X,σ⟩
	⟨X,σ:{CAT:verb,AGR(su):{PERS:1,NUM:pl}}⟩	⟶	⟨*tu*X,σ⟩
	⟨X,σ:{CAT:verb,AGR(su):{PERS:2,NUM:pl}}⟩	⟶	⟨*m*X,σ⟩
	⟨X,σ:{CAT:verb,AGR(su):{PERS:3,NUM:pl},GEN:{1,2}}⟩	⟶	⟨*wa*X,σ⟩
Block C	⟨X,{CAT:verb, POL:neg}⟩	⟶	⟨*ha*X,σ⟩

Recall that the identity function, ⟨X,σ⟩ ⟶ ⟨X,σ⟩, is a member of every rule block, according to the IFD. Thus, we see for example, that the negated third singular past tense form is correctly predicted to be *ha-a-ku*-ROOT and not **ha-a-li*-ROOT,

[10]Note that, in this literature, the term *portmanteau* has a more restrictive use than we how we use it here. What we have been calling a portmanteau would be called *cumulative exponence*.

[11]The simplification does not account for all the nuances of the paradigms that are captured by the rules in Stewart & Stump (2007).

because the portmanteau form *ku* expresses both the past tense and the negation. From Block A, then, the third rule must be chosen. From Block B, the third rule best expresses the features. Lastly, the rule in Block C can apply, given the input features. The result is the well-formed *ha-a-ku*-ROOT, which undergoes phonological shortening to *ha-ku*-ROOT.

Sadler & Nordlinger (2004) presented an LFG interface to PFM for case-stacking in Australian languages that display that phenomenon (e.g., Kayardild, Martuthunira, Thalanyji, Wambaya). Sadler & Nordlinger (2006) subsequently presented the actual PFM morphology, i.e. realization, of case-stacking morphology. The two papers together constitute an instance of LFG interfaced with PFM. Sadler & Nordlinger (2004: 172–180) provide a detailed analysis of the following example from Martuthunira (Dench 1995: 60, (3.15)):

(17) Martuthunira

Ngayu	nhawu-lha	ngurnu	tharnta-a	mirtily-marta-a
I	saw-PST	that.ACC	euro-ACC	joey-PROP-ACC

thara-ngka-marta-a.
pouch-LOC-PROP-ACC

1 saw the euro with a joey in (its) pouch.

Sadler & Nordlinger (2004: 174, (28)) provide the following lexemic entry[12] for the word *tharangkamartaa* in (17):

(18) $\langle$*thara*, {Case$_C$: LOC, {Case$_C$: PROP, {Case$_C$: ACC}}}$\rangle$

Sadler & Nordlinger (2004: 174, (25)) provide the following interpretations of these case features:[13]

(19)

M-feature	F-description
Case$_C$: LOC	$(\uparrow \text{CASE}) = \text{LOC}$
	$(\text{ADJ}_{loc} \in \uparrow)$
Case$_C$: PROP	$(\uparrow \text{CASE}) = \text{PROP}$
	$(\text{ADJ}_{prop} \in \uparrow)$
Case$_C$: ACC	$(\uparrow \text{CASE}) = \text{ACC}$
	$(\text{OBJ} \uparrow)$

[12] We use the terminology of Dalrymple 2015; see Section 4 above.

[13] Their table does not include ACC but what its entry should be is clear from their (30) (Sadler & Nordlinger 2004: 175). Also, we have adjusted for the feature ADJ being set-valued by using the $\in$.

In the Dalrymple (2015) notation this would be:[14]

(20) $\mathit{LE}\langle\{\textsc{root}\text{: pouch}\}, \{(\uparrow\textsc{pred}) = \textsc{pouch}\}, \textsc{pouch1}\rangle$

$\mathit{R}\langle\textsc{pouch1}\text{, tharangkamartaa, /ṯaraŋkamaṯaa/,}$
$\quad\text{m-feats:}\{\textsc{m-cat:n}, \textsc{m-case: loc}, \{\textsc{m-case: prop}, \{\textsc{m-case: acc}\}\}\}\rangle$

$$\begin{array}{ll}
\mathit{D}\langle\textsc{pouch1}\text{, m-feats, N, } & (\uparrow\textsc{num}) = \textsc{sg} \\
& (\uparrow\textsc{case}) = \textsc{loc} \\
& (\textsc{adj}_{loc} \in \uparrow) \\
& ((\textsc{adj}_{loc} \in \uparrow)\ \textsc{case}) = \textsc{prop} \\
& (\textsc{adj}_{prop} \in \textsc{adj}_{loc} \in \uparrow) \\
& (((\textsc{adj}_{prop} \in \textsc{adj}_{loc} \in \uparrow))\ \textsc{case}) = \textsc{acc} \\
& (\textsc{obj}\ \textsc{adj}_{prop} \in \textsc{adj}_{loc} \in \uparrow)\rangle
\end{array}$$

$$\begin{array}{l}
\mathcal{L}\langle\text{tharangkamartaa, /ṯaraŋkamaṯaa/,} \\
\quad \text{N, } \{(\uparrow\textsc{pred}) = \textsc{pouch} \\
\qquad (\uparrow\textsc{num}) = \textsc{sg} \\
\qquad (\uparrow\textsc{case}) = \textsc{loc} \\
\qquad (\textsc{adj}_{loc} \in \uparrow) \\
\qquad ((\textsc{adj}_{loc} \in \uparrow)\ \textsc{case}) = \textsc{prop} \\
\qquad (\textsc{adj}_{prop} \in \textsc{adj}_{loc} \in \uparrow) \\
\qquad (((\textsc{adj}_{prop} \in \textsc{adj}_{loc} \in \uparrow))\ \textsc{case}) = \textsc{acc} \\
\qquad (\textsc{obj}\ \textsc{adj}_{prop} \in \textsc{adj}_{loc} \in \uparrow)\}\rangle
\end{array}$$

This complex lexical entry $\mathcal{L}_{tharangkamartaa}$ licenses the following f-structure:

(21)
$$\begin{bmatrix} \textsc{obj} & \begin{bmatrix} \textsc{case} & \textsc{acc} \\ \textsc{adj}_{prop} & \left\{ \begin{bmatrix} \textsc{case} & \textsc{prop} \\ \textsc{adj}_{loc} & \left\{ \begin{bmatrix} \textsc{pred} & \textsc{pouch} \\ \textsc{num} & \textsc{sg} \\ \textsc{case} & \textsc{loc} \end{bmatrix} \right\} \end{bmatrix} \right\} \end{bmatrix} \end{bmatrix}$$

Thus, we can observe that the Dalrymple (2015) notation accurately reconstructs the intended f-structure from Sadler & Nordlinger (2004: 178, (36)).[15]

However, some work remains to be done. How is the realization of *tharangkamartaa* determined based on the root, lexemic ID, and the m-features? The Dalrymple (2015) framework is silent on this issue, because it is meant to be a *general*

[14]The $(\uparrow\textsc{num}) = \textsc{sg}$ part of the f-description occurs by default, following the assumption in Dalrymple (2015: 76) that singular number is the default for nouns (i.e., M-CAT:N in the absence of M-NUM introduces the f-description $\{(\uparrow\textsc{num}) = \textsc{sg}\}$).

[15]Modulo our use of $\in$, which they simplify away, and the [NUM SG], which comes from Dalrymple's default; see footnote 14 above.

interface between LFG syntax and realizational morphology. In order to preserve its generality, the framework remains silent on the question of exponence. As mentioned above, Sadler & Nordlinger (2006) provide a PFM account, which we can plug into the Dalrymple framework. Adapting their proposal (Sadler & Nordlinger 2004: 471, 23) — which in any case is for Kayardild, not Martuthunira — we get the following case rule block, using the Dalrymple (2015) *R* function:

(22) a. *R*⟨POUCH1, tharangka, /ṯaraŋka/,
{M-CAT:N, M-CASE: LOC}⟩

b. *R*⟨POUCH1, tharangkamarta, /ṯaraŋkamaṯa/,
{M-CAT:N, M-CASE: PROP}⟩

c. *R*⟨POUCH1, tharangkamartaa, /ṯaraŋkamaṯaa/,
{M-CAT:N, M-CASE: ACC}⟩

The effect of these functions on the s-form can be captured in the following simplified PFM representation, based on (15).[16]

(23) $\langle X,\sigma{:}\{\textsc{m-cat:n, m-case:loc}\}\rangle \longrightarrow \langle X\textit{ngka},\sigma\rangle$
$\langle X,\sigma{:}\{\textsc{m-cat:n, m-case:prop}\}\rangle \longrightarrow \langle X\textit{marta},\sigma\rangle$
$\langle X,\sigma{:}\{\textsc{m-cat:n, m-case:acc}\}\rangle \longrightarrow \langle X\textit{a},\sigma\rangle$

In other words, in the context of the features M-CAT:N and M-CASE:LOC, the input exponent becomes extended with additional morphological information, the suffix *ngka*. In the context of the features M-CAT:N and M-CASE:PROP, the input exponent becomes extended with additional morphological information, the suffix *marta*. And, in the context of the features M-CAT:N and M-CASE:ACC, the input exponent becomes extended with additional morphological information, the suffix *a*.

In sum, much work in LFG has adopted Paradigm Function Morphology as its morphological theory. PFM is an *inferential-realizational* theory of morphology. It is *lexemic*, it is *Word-and-Paradigm*, and it assumes *Strong Lexicalism*.

5.2 The targets of exponence

What realizational theories have in common is that morphology realizes things; what they don't have in common is what those things are. In a paradigm model, like PFM, morphology realizes a lexeme and a valuation of a fixed set of attributes.

[16] Note that the simplified formalization in (23) does not account for the set-based embedding in (17) above. But it should be easy enough to replace the second coordinate of the input to their function with **contains**(f), where **contains** is a function that recursively searches σ for its argument, f, a feature, e.g. M-CASE:LOC.

It must be a *fixed* set of attributes, by definition of a paradigm. As Spencer (2013: 9) notes:

> On this … conception we abstract away from actual word forms and just consider the set of oppositions or contrasts that are available in principle to a lexeme.

"The set of cells embodying the set of oppositions open to a lexeme" is what Spencer (2013: 9) calls the *property paradigm*. It's *this* abstraction, the property paradigm, that is realized by word forms (the *form paradigm*) in what Spencer calls the *form-property paradigm* (Spencer 2013: 9). In this kind of conception, in order to preserve Strong Lexicalism one must simply have an intervening function that maps a lexeme to a syntactic word:

(24) form-property paradigm $\xrightarrow{f}$ set of instantiated lexical entries for syntax

The mapping f can be a structured mapping, if there are features of the mapping itself that the grammar needs to refer to. This could be represented as an attribute-value matrix. In other words, m-structure (see above) is one possible characterization of the structured mapping f. And an AVM is also indeed how Spencer (2013) models the structured mapping f; see Figure 5. This paradigm shows the lexeme DELATʹ ('make') from Russian, which has stem alternants in the present (*delaj-*), infinitive (*dela-*), and predicative adjective (*delal-*).

Ackerman & Stump (2004) make an antecedent proposal to that of Spencer (2013) which is very similar, although not as well-developed (as a consequence of the former being a paper and the latter a monograph). However, it is worth reading the following passage from Ackerman & Stump (2004) to get a different perspective on the form-property paradigm of Spencer (2013), especially because it refers more directly to LFG structures:

> In distinguishing a lexeme's content-theoretic aspects from its form-theoretic aspects, we will pursue an innovative conception of the lexicon and its relation to c-structure, f-structure, and morphological realization. On this conception, a language's lexicon is bipartite with respect to content and form: one part of its lexicon is its LEXEMICON, whose individual entries are lexemes bearing lexical meanings: the complementary part is its RADICON, whose individual entries are roots, i.e. elements of form. Every member L of a language's lexemicon has an associated CONTENT-PARADIGM C-P(L) such that each cell in C-P(L) consists of the pairing of L with a complete set of morphosyntactic properties; we refer to any such pairing as a

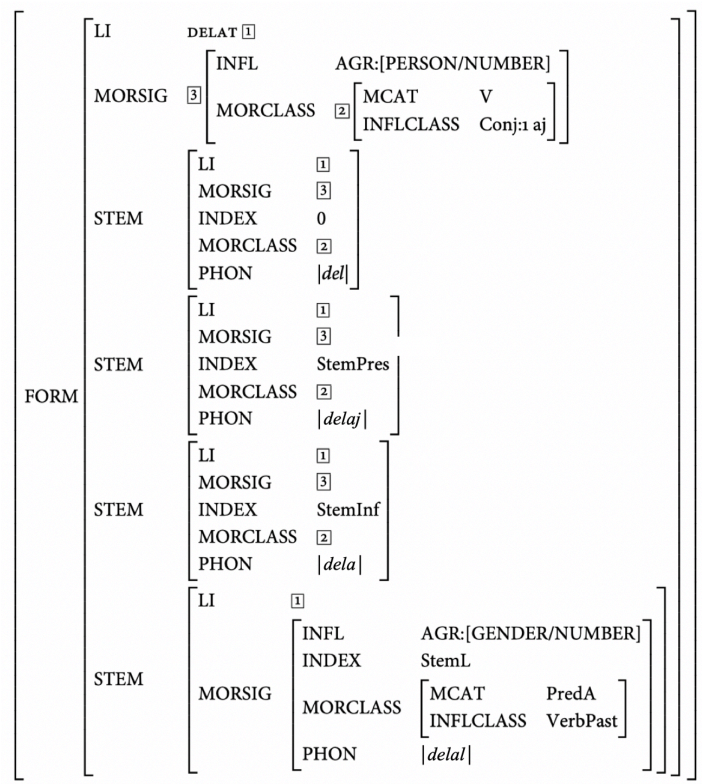


Figure 5: The form-property paradigm for Russian DELAT′ ('make'). From Spencer (2013: 263, (56)); used with permission.

> CONTENT-CELL. Crucially, content-cells represent ensembles of semantically interpretable information. In contrast, every member r of a language's radicon has an associated FORM-PARADIGM F-P(r) such that each cell in F-P(r) consists of the pairing of r with a set of differentiating morphosyntactic property labels; we refer to any such pairing as a FORM-CELL. A language's paradigms of form-cells house the information necessary to deduce the morphological realization of the cells in that language's content-paradigms. (Ackerman & Stump 2004: 117–118)

Although their terminology is different, there are obvious correspondences with Spencer (2013). Ackerman & Stump (2004) assume that a lexicon consists of two parts. The first part is the LEXEMICON, which "has an associated CONTENT-PARADIGM". Their content-paradigm corresponds to Spencer's property paradigm. The second part of the lexicon for Ackerman & Stump (2004) is the RADICON, which “has an associated FORM-PARADIGM”. Their form-paradigm corresponds to Spencer’s form paradigm. Taken together, then, Ackerman & Stump’s (2004) lexicon is equivalent to a set of Spencer’s (2013) form-property paradigms. As a consequence, the mapping in (24) above also accurately characterizes the Ackerman & Stump (2004) proposal, which is about periphrasis — when a paradigm cell is filled by more than one word. Further work in this vein can be found in, e.g., Ackerman et al. (2011) and Spencer (2015). We have chosen to describe the Spencer (2013) and Ackerman & Stump (2004) work because of their close connection to LFG, but PFM2 (Stump 2016) incorporates similar principles.

The important takeaway here is that in lexemic morphology there is a mapping (structured or not) from an abstract property paradigm — whose features are purely morphological — to syntax. One could imagine instead having morphology realize the syntactic representation(s) directly, which is the approach taken in Distributed Morphology (DM; Halle & Marantz 1993), and theories like it (e.g., Nanosyntax; Starke 2009, Caha 2009). This comes at the expense of (at least some of) Strong Lexicalism, as discussed below in reference to (38), but it does away with the abstraction of the property paradigm. In a morphemic model, like DM, morphology realizes the information in the terminals of some syntactic representation. There will necessarily be information about syntax, but also possibly about semantics and other aspects of grammar (if they are modelled separately).

5.3 LFG interfaced with DM

In Section 5.1, we explored LFG paired with PFM, an inferential-realizational framework for morphology. In this section, we see LFG paired with Distributed Morphology, a lexical-realizational framework. This combination is called Lexical-Realizational Functional Grammar ($\mathrm{L_RFG}$; Asudeh & Siddiqi 2016, Melchin et al. 2020, Everdell et al. 2021, Asudeh & Siddiqi forthcoming). $\mathrm{L_RFG}$ accomplishes this synthesis of LFG and DM by mapping information from the c-structure to a realization, or *exponent*, called *vocabulary structure*.

Importantly, $\mathrm{L_RFG}$ assumes that c-structure terminals are not *words*, but just grammatical and semantic information, with no associated information about the form (e.g., *s-form*; see Section 4.1) included in the c-structure. This fact, together with the fact that $\mathrm{L_RFG}$ follows DM in postulating highly articulated morphological structure, differentiates $\mathrm{L_RFG}$ c-structures from LFG c-structures. However, $\mathrm{L_RFG}$ uses the LFG formal machinery and assumes the same kinds of annotated c-structure rules. In $\mathrm{L_RFG}$, the categorial information in c-structure *preterminals* and the other information in c-structure *terminals* are realized by L$_R$FG's ν correspondence function as v(ocabulary)-structures. Since L$_R$FG assumes a version of LFG's Correspondence Architecture (Kaplan 1989, 1995), the information that v-structures express is not *purely* syntactic. V-structures also express information about semantics (encoded in Glue Semantics *meaning constructors*: see Asudeh forthcoming [this volume]) and can indeed express information structure or any other aspect of grammar that is encoded in distinct modules in the Correspondence Architecture.

L$_R$FG seeks to add to LFG's strengths in accounting for *nonconfigurationality* by adding DM's strengths in accounting for *polysynthesis*. These two properties co-occur with some frequency in non-European languages. L$_R$FG also seeks to account for highly agglutinative languages like Finnish and Turkish. Additionally, because the realizational module, v-structure, interfaces with prosodic structure, L$_R$FG draws on existing LFG work, especially Bögel (2015), on clitic ordering and extends it to affixation. Asudeh et al. (2022) develops the interface between v-structure and p(rosodic)-structure (by the ρ correspondence function) and the mapping from p-structure to the p(honological)-string (by the o correspondence function).

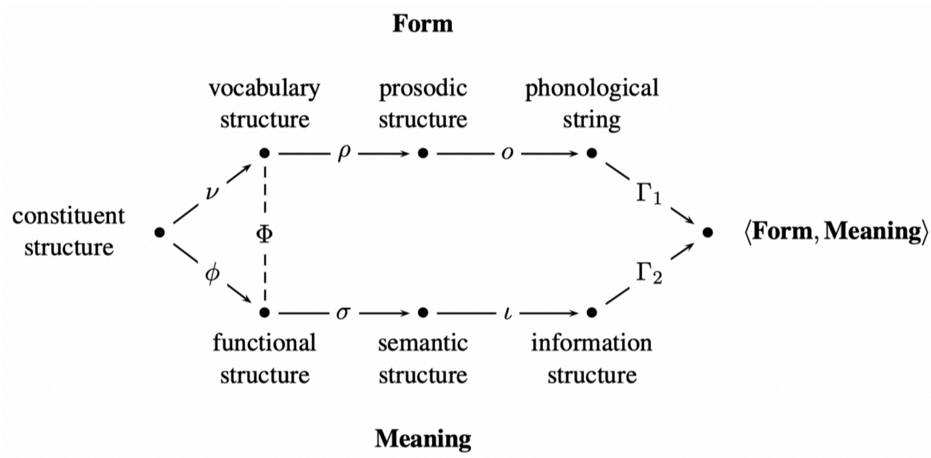


Figure 6: L$_R$FG's version of LFG's Correspondence Architecture. From Melchin et al. (2020: 271); used with permission.

L$_R$FG's version of LFG's Correspondence Architecture is shown in Figure 6, which shows that there is a lot shared between L$_R$FG and LFG. However, there is no lexicon feeding the c-structure in L$_R$FG. Rather, there is a Vocabulary in L$_R$FG that consists of a set of mappings from n-tuples that contain categorial information and an f-description to vocabulary structures that realize the content of the input. In recent L$_{\mathrm{R}}$FG work on morphosemantics (Asudeh & Siddiqi 2022), we suggest that, for the purposes of the *ν*-mapping, the f-description could be usefully partitioned into a set consisting of information about non-f-structural aspects of the grammar (in particular, Glue meaning constructors for compositional semantics) and the set consisting of the rest of the f-description, which is information about f-structure.[17] The following example shows Vocabulary Items (VIs) for Ojibwe and English roots for *see* (Asudeh & Siddiqi 2022):[18]

(25) Ojibwe

$\langle\ [\sqrt{\ \ }], \Phi\{(\uparrow \textsc{pred}) = \textsc{see}\}, \{\mathbf{see} : (\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma\}\ \rangle \xrightarrow{\nu} \textit{waab}$

(26) English

$\langle\ [\sqrt{\ \ }], \Phi\{(\uparrow \textsc{pred}) = \textsc{see}\}, \{\mathbf{see} : (\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma\}\ \rangle \xrightarrow{\nu} \textit{see}$

The first coordinate of the input is a list of c-structure categories, typically of length 1. However, it is actually an ordered list of preterminals from the c-structure, such that the list can be longer in cases of *spanning* (Ramchand 2008, Haugen & Siddiqi 2016, Svenonius 2016, Merchant 2015), which is used in some versions of DM for *portmanteau* phenomena. The result is similar to the Lexical Sharing model proposed for LFG by Wescoat (2002, 2005, 2007), but maintains, like DM, that the complex internal structures of words are part of syntax.

In the cases above, the list is of length 1 and has the sole category $\sqrt{\ \ }$, the category of all roots. The second coordinate uses the *bridging function*, Φ, to map the f-description to the set of f-structures that it describes. The third coordinate is not subject to Φ and contains semantic information modelled in Glue meaning constructors.

Meaning constructors are pairs of terms from two logics (the colon is an uninterpreted pairing symbol):

(27) $\mathcal{M} : G$

$\mathcal{M}$ is an expression of the *meaning language* — anything that supports the lambda calculus. G is an expression of *linear logic* (Girard 1987), which specifies semantic composition based on a syntactic parse that instantiates the general terms in G to a specific syntactic structure.

The meaning constructors serve as premises in a linear logic proof of the *compositional semantics*. Consider example (28).

[17] The new third coordinate could potentially also include i-structural information; or perhaps this would be better captured in a separate fourth coordinate. We plan to explore this in future work.

[18] We will present the *bridging function*, Φ, shortly.

(28) Alex likes Blake.

We obtain the following meaning constructors from the relevant VIs.

(29) Meaning constructors: $\mathbf{alex} : a$
$\mathbf{blake} : b$
$\lambda y.\lambda x.\mathbf{like}(y)(x) : b \multimap a \multimap l$

Note that $\lambda y.\lambda x.\mathbf{like}(y)(x)$ is η-equivalent to just **like**, but it is useful to use the expanded form to make the structure of the following proof more obvious.

(30)
$$\dfrac{\boxed{\mathbf{alex} : a} \qquad \dfrac{\boxed{\lambda y.\lambda x.\mathbf{like}(y)(x) : b \multimap a \multimap l} \qquad \boxed{\mathbf{blake} : b}}{\lambda x.\mathbf{like}(\mathbf{blake})(x) : a \multimap l}}{\mathbf{like}(\mathbf{blake})(\mathbf{alex}) : l}$$

In the proof, the meaning constructors in (29) are shown in boxes to aid the reader less familiar with Glue; this is not a part of the proof as such. It highlights the meaning constructors versus the compositionally derived meanings. For brief overviews of Glue Semantics, see Asudeh (2022); Asudeh forthcoming [this volume].

Recall the Vocabulary Item for Ojibwe *waab* in (25):

(31) $\langle\ [\sqrt{}],\ \Phi\{(\uparrow\textsc{pred}) = \textsc{see}\}, \{\mathbf{see} : (\uparrow\textsc{obj})_\sigma \multimap (\uparrow\textsc{subj})_\sigma \multimap \uparrow_\sigma\}\ \rangle \xrightarrow{\nu} \textit{waab}$

This information can be represented as follows in a c-structure:

(32)
$$\begin{array}{c}\sqrt{}\\ |\\ (\uparrow \textsc{pred}) = \text{‘see’}\\ \mathbf{see} : (\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma\end{array}$$

The c-structure is licensed by c-structure rules of the usual kind, but containing categories like $\sqrt{}$, which are less familiar in LFG. Thus, the annotated c-structure rule for licensing (32) in a c-structure would be as follows, leaving the mother category underspecified and similarly the sister of $\sqrt{}$:

(33)
$$\mathrm{X}^n \longrightarrow \underset{\uparrow=\downarrow}{\sqrt{}} \quad \underset{\uparrow=\downarrow}{\mathrm{X}^{m,\ m\leq n}}$$

Note that it is X^m that projects the c-structure mother X^n in a co-head structure with $\sqrt{}$. Thus, X is necessarily a functional category (Bresnan et al. 2016: ch. 6).

In short, we can think of the lefthand side of a Vocabulary Item as a tree admissibility condition (McCawley 1968) on a subtree whose preterminal yield is the list of categories in the first coordinate of the ν function such that the f-description in the second coordinate and the meaning constructors in the third are the union of its terminal yield. Alternatively, we can think of it in terms of terminal expansions, such as:

(34) $$\sqrt{} \longrightarrow \left\{ \begin{array}{c} \{(\uparrow \textsc{pred}) = \textsc{see}, \mathbf{see} : (\uparrow \textsc{obj})_\sigma \multimap (\uparrow \textsc{subj})_\sigma \multimap \uparrow_\sigma\}, \\ \vdots \end{array} \right\}$$

We prefer the tree admissibility route, but observe that whether we go that route or the terminal expansion route, there is no information about form in the input side of the Vocabulary Item. That is the job of the ν correspondence function. Recall that ν maps the information in c-structure terminals and c-structure categorial information to v-structures, as shown in (25–26).

Here is an example from Ojibwe (*Anishinaabemowin*, Algonquian; Melchin et al. 2020: 288):

(35) Ojibwe

gi-	gii-	waab	-am	-igw	-naan	-ag
2	PST	see	VTA	INV	1PL	3PL

'They saw us(incl).'

The $\mathrm{L_RFG}$ c-structure and f-structure and the ν correspondence from c-structure to v-structure are shown in Figure 7 (Melchin et al. 2020: 288). Note that we have only shown the form part of each v-structure, and only using an orthographic rather than phonemic representation. V-structures also minimally contain prosodic information — such as information about phonological dependency (e.g., for *clisis*) and the identity of the host (e.g., for *affixation*) — and any purely morphological information (e.g., *inflectional class*). Asudeh et al. (2022) propose the v-structure representation that is schematized in (36).

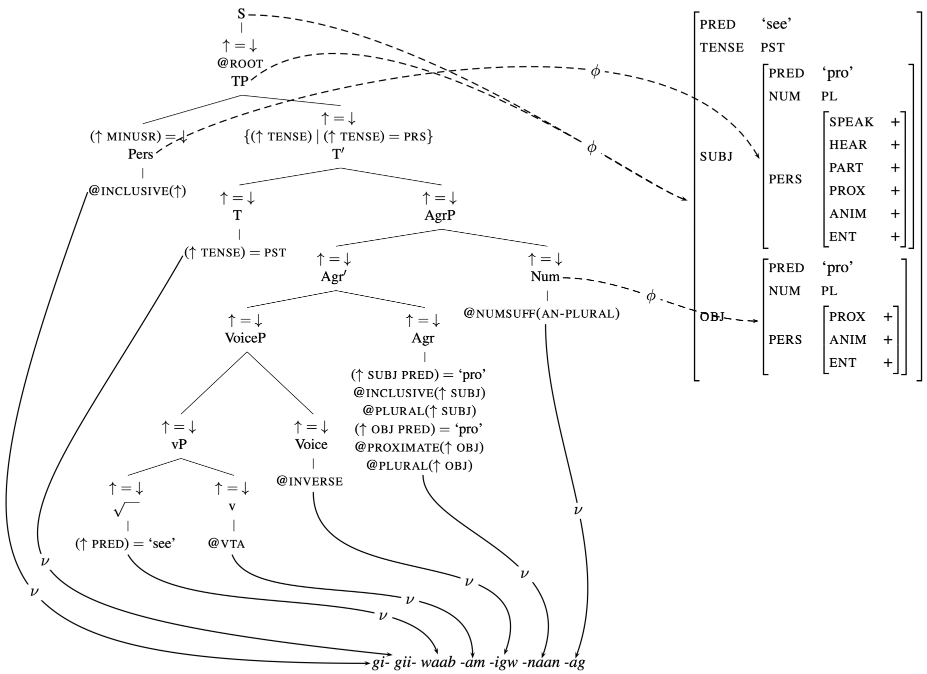


Figure 7: L_RFG c-structure, f-structure, and (simplified) v-structure for Ojibwe *gigiiwaabamigwnaanag* ('They saw us(incl)')

(36)
$$\left[\begin{array}{ll}
\textsc{phon}(\textsc{ological}) & \\
\textsc{rep}(\textsc{resentation}) & \textit{phonological realization \& conditions} \\
\textsc{p}(\textsc{rosodic})\textsc{frame} & \textit{prosodic unit} \\
\textsc{p}(\textsc{rosodic})\textsc{level} & 1|2 \\
\textsc{dep}(\textsc{endence}) & \{\textsc{left,right}\} \\
\textsc{class} & \{\textit{inflectional classes}\} \\
\textsc{type} & \textsc{verbal}|\textsc{nominal}|\textsc{adjectival} \\
\textsc{host} & \left[\begin{array}{l}
\textsc{identity} \;\; \textsc{aunt}|\textsc{niece} \\
\left\{\left[\begin{array}{ll}
\textsc{phon.rep} & \ldots \\
\textsc{pframe} & \ldots \\
\textsc{plevel} & \ldots \\
\textsc{class} & \ldots \\
\textsc{type} & \ldots
\end{array}\right]\right\}
\end{array}\right]
\end{array}\right]$$

A v-structure is thus a feature structure that minimally contains information about form and morphophonology (PHON.REP, PFRAME, PLEVEL, and DEP), properly morphological information (CLASS, TYPE), and morphosyntactic information about its HOST, where relevant. All features can be left underspecified (i.e., when they are not mentioned in the description that defines the v-structure).

The obvious point of contrast between L_RFG and LFG concerns the Lexicalist Hypothesis (Chomsky 1970, Lapointe 1980):

(37) *Lexicalist Hypothesis*
No syntactic rule can refer to elements of morphological structure.
(Lapointe 1980: 8)

In LFG, this is captured in the *Lexical Integrity Principle*, through formulations like the following:

(38) *Lexical Integrity*
Morphologically complete words are leaves of the c-structure tree, and each leaf corresponds to one and only one c-structure node.
(Bresnan et al. 2016: 92)

This statement has two parts:

1. L_RFG *upholds* the part that states that "each leaf corresponds to one and only one c-structure node".

2. L_RFG *rejects* the part that states that "morphologically complete words are leaves of the c-structure tree".

Clearly, the c-structure leaves/terminals in L_RFG are not "morphologically complete words". The c-structure leaves/terminals are feature bundles that *map* to form, but the form itself is not part of the terminal node; hence 2. Yet there is never multidominance in an L_RFG c-structure; hence 1.

However, notice that the notion *morphologically complete word* is left unanalyzed in the definition in (38). In fact, it is far from clear that "morphologically complete word" is a coherent notion (for discussion, see e.g., Anderson 1982). The essential problem is that there are multiple relevant notions of wordhood, and they don't align on a single type of object that we can point to and unambiguously and confidently call a word (Di Sciullo & Williams 1987).[19] In fact, there can be mismatches between the phonological, syntactic, and semantic aspects of words (Marantz 1997). Of course, the LFG Correspondence Architecture is designed around the notion of mismatches between modules, which is carried over into L_RFG.

[19]This is a long and broad discussion that we cannot possibly do justice to here.

5.3.1 Conditions on exponence

Recall that the exponence function ($\xrightarrow{\nu}$) is a triple to a v-structure. The first argument of the triple is a list of preterminal categories, typically of length 1, which are taken in the linear order they appear in the tree. The second argument is itself a function, Φ, which maps an f-description to the set of f-structures that satisfy the description; i.e. $\Phi(d \in D) = \{f \in F \mid f \vDash d\}$, where D is the set of valid f-descriptions and F is the set of f-structures.[20] The third argument is a set that includes *meaning constructors* from Glue Semantics (Glue; Dalrymple 1999, 2001, Dalrymple et al. 2019, Asudeh 2012, 2022).

Let V^i be the domain of the exponence function ν in some language L, i.e. the set of inputs to Vocabulary Items in L. We write $V^i(\alpha)$ to indicate the domain of some particular Vocabulary Item, α. We write $\pi_n(V^i(\alpha))$ to indicate the n^{th} projection of $V^i(\alpha)$. For example, $\pi_1(V^i(\alpha))$ returns the c-structure list in the first projection of the input to Vocabulary Item α.[21] The following conditions on exponence hold based on the input side of the ν correspondence function (Asudeh & Siddiqi 2022).[22]

(39) **MostInformative**$_c(\alpha, \beta)$ returns whichever of α,β has the longest list of overlapping c-structure categories.
Intuition. Prefer portmanteau forms, whenever possible, on c-structural grounds. Choose the VI that realizes the greater list of categories.

Formalization. We define a function **span** that compares two lists for overlap.[23]
Given two Vocabulary Items, α and β,

$$\textbf{MostInformative}_c(\alpha,\beta) = \begin{cases} \alpha \textbf{ if } \pi_1(V^i(\alpha)) = f \wedge \pi_1(V^i(\beta)) = g \ \wedge\ \textbf{span}(f,g) \\ \beta \textbf{ if } \pi_1(V^i(\alpha)) = f \wedge \pi_1(V^i(\beta)) = g \ \wedge\ \textbf{span}(g,f) \\ \perp \textbf{ otherwise} \end{cases}$$

(40) **MostInformative**$_f(\alpha, \beta)$ returns whichever of α,β has the most specific f-structure in the set of f-structures returned by Φ applied to α/β's collected f-description.

[20] We thank Ron Kaplan (p.c.) for discussion of this point. Any remaining errors are our own.

[21] This π is just standard notation for retrieving arguments to functions and should not be mistaken for a correspondence function.

[22] Note that all these conditions are Paninian, as is typical in morphological analysis. The analog in PFM is actually called Panini's Principle (Stump 2001) and in DM it is called the Subset Principle (Halle & Marantz 1993).

[23] Asudeh & Siddiqi (2022) define **span** as follows:

$$\textbf{span}(list_1, list_2) = \begin{cases} \mathsf{first}(list_1) = \mathsf{first}(list_2) \wedge \textbf{span}(\mathsf{rest}(list_1), \mathsf{rest}(list_2)) \\ list_1 \neq elist \ \wedge\ list_2 = elist \end{cases}$$

Intuition. Prefer portmanteau forms, whenever possible, on f-structural grounds. Choose the VI that defines an f-structure that contains the greater set of features.

Formalization. The proper subsumption relation on f-structures (Bresnan et al. 2016: chap. 5) is used to capture the intuition.
Given two VIs, α and β,

$$\textbf{MostInformative}_f(\alpha,\beta) = \begin{cases} \alpha \text{ if } \exists f \forall g. f \in \pi_2(V^i(\alpha)) \land g \in \pi_2(V^i(\beta)) \land g \sqsubset f \\ \beta \text{ if } \exists f \forall g. f \in \pi_2(V^i(\beta)) \land g \in \pi_2(V^i(\alpha)) \land g \sqsubset f \\ \bot \text{ otherwise} \end{cases}$$

(41) **MostInformative**$_s(\alpha,\beta)$ returns whichever Vocabulary Item has the more specific meaning.
Intuition. Prefer portmanteau forms, wherever possible, on semantic grounds. Choose the VI whose denotation is more semantically contentful.
Formalization. The proper subset relation on set-denoting expressions is used to capture the intuition.
Given two Vocabulary Items, α and β,

$$\textbf{MostInformative}_s(\alpha,\beta) = \begin{cases} \alpha \text{ if } f = \pi_3(V^i(\alpha)) \land g = \pi_3(V^i(\beta)) \land [\![f]\!] \subset [\![g]\!] \\ \beta \text{ if } f = \pi_3(V^i(\alpha)) \land g = \pi_3(V^i(\beta)) \land [\![g]\!] \subset [\![f]\!] \\ \bot \text{ otherwise} \end{cases}$$

In addition, there is a constraint on exponence that concerns the output of the ν correspondence function (Asudeh & Siddiqi 2022), i.e. the expression of prosodic and phonological information. Let V^o be the co-domain of the exponence function ν in some language L, i.e. the set of outputs of Vocabulary Items in L. We write $V^o(\alpha)$ to indicate the co-domain of some particular Vocabulary Item, α (i.e., the output vocabulary structure).

(42) **MostSpecific**(α,β) returns whichever Vocabulary Item has the most restrictions on its phonological context.

Intuition. Prefer affixes whenever possible.

Formalization. The proper subsumption relation on feature structures — i.e., v-structures — is used to capture the intuition.
Given two Vocabulary Items, α and β,

$$\textbf{MostSpecific}(\alpha,\beta) = \begin{cases} \alpha \text{ if } (V^o(\beta)\ \textsc{host}) \sqsubset (V^o(\alpha)\ \textsc{host}) \\ \beta \text{ if } (V^o(\alpha)\ \textsc{host}) \sqsubset (V^o(\beta)\ \textsc{host}) \\ \bot \text{ otherwise} \end{cases}$$

The upshot is that **MostSpecific** chooses the VI whose output v-structure has more specific content in the HOST feature.[24]

Note that **MostInformative**$_c$ and **MostInformative**$_f$ are *morphosyntactic* constraints, **MostInformative**$_s$ is a *morphosemantic* constraint, and **MostSpecific** is a *morphophonological* constraint. Note also that each constraint can result in a tie, represented by ⊥. However, there are regularities in the mappings/interfaces between structures, so it would be unlikely for all four constraints to yield ⊥. We are not currently aware of any empirical case that would merit such an analysis. Lastly, it is important to note that these constraints apply simultaneously and universally (whenever they can), much like standard constraints and equations in LFG. There is no constraint-ordering and the constraints are not soft constraints.[25]

In sum, L$_R$FG is a daughter framework of LFG that uses the LFG formalism in a conservative fashion. However, L$_R$FG theory makes some different assumptions from traditional LFG theory. Namely, it rearranges the Correspondence Architecture, adds a new structure with new properties (v-structure), upholds only part of the Lexical Integrity Principle, and has a more articulated c-structure than standard LFG, in order to provide a morphemic theory of morphology. These theoretical distinctions are due to the influence of DM, since L$_R$FG is also a daughter framework of DM.

As its name states, Lexical-Realizational Functional Grammar is a *lexical-realizational* theory of morphology. It is *morphemic*, *Item-and-Arrangement*, and *morphosyntactic*.

6 Conclusion

A feature of LFG is its f-descriptions, which can occur in both lexical entries and on c-structure nodes. The result is that both morphology and syntax can contribute information to f-structure. This ‘common language’ between morphology and syntax has allowed LFG to remain agnostic about the precise nature of

[24]Note that if (f FEAT) does not exist, (f FEAT) resolves to the empty feature structure, notated ⊥ (not to be confused with the ⊥ explicitly mentioned in the constraints above). as it’s the bottom of the f-structure lattice. The empty f-structure subsumes all f-structures. Therefore, if (v HOST) does not exist, but (v' HOST) does exist, then (v HOST) $\sqsubset$ (v' HOST) returns true. If (v' HOST) also does not exist, then (v HOST) $\sqsubset$ (v' HOST) returns false, since it is false that ⊥ *properly* subsumes ⊥.

[25]An anonymous wonders what the system would do if one constraint picks α and another picks β. This is an interesting point that deserves further investigation and we thank the reviewer for highlighting it.

morphology. In its initial construal as just a theory of syntax, based around c-structure and f-structure, this was pretty harmless. But once a general grammatical architecture, the Correspondence Architecture, was proposed (Kaplan 1989, 1995), LFG began to owe a better account of how it interfaces with morphology.

In early LFG, morphology was generally done incrementally, using annotated phrase structure rules of the same kind that license c-structures, but whose categories are morphological instead of syntactic. Morphological theory in general, though, has been converging on the idea that morphology is realizational, not incremental. Therefore, more recent work has focused on exploring the syntax–morphology interface (Dalrymple 2015, Dalrymple et al. 2019: ch. 12) in light of an interface with realizational morphology. This work can be thought of as providing a universal adapter between LFG syntax and some kind of realizational morphology. Much of the theoretical work on morphology for LFG over the last couple of decades has focused on interfacing LFG with Paradigm Function Morphology. Other recent work has presented an alternative in the guise of $\mathrm{L_R}$FG, a framework that instead interfaces LFG with Distributed Morphology.

The existence of two different approaches to morphological realization in LFG, i.e. PFM and $\mathrm{L_R}$FG, mirrors two different interpretations of 'morphological complexity' as a set of phenomena requiring explanation. *Paradigmatic* morphological complexity (see, e.g., Baerman et al. 2017) concerns complex patterns of syncretism, root allomorphy, and templatic morphology. *Syntagmatic* morphological complexity concerns concatenative morphology whose structures seem to encode syntactic structure, in other words structure *within* what we pretheoretically call words. PFM addresses the former kind of morphological complexity, while $\mathrm{L_R}$FG addresses the latter.

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for the inspiration that her own work on morphology in LFG has provided us. All remaining errors and misconceptions are our own.

Abbreviations

Besides the abbreviations from the Leipzig Glossing Conventions, this chapter uses the following abbreviations.

INV	inverse voice
PROP	proprietive case
VTA	verb transitive animate object

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Chapter 8

LFG and Tree Adjoining Grammar

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This chapter gives an introduction to Tree-Adjoining Grammar (TAG) and draws some comparisons with Lexical Functional Grammar (LFG). It is primarily aimed at those familiar with LFG who are looking to learn about TAG and see where the two formalisms differ/overlap, but the comparisons will also be of interest to those coming from a TAG background. After introducing TAG, the chapter considers questions of generative capacity, lexicalisation, and the factoring of redundancies from grammars. It then concludes by illustrating the potential for combining LFG and TAG, and discusses the theoretical implications of doing so.

1 Introduction and roadmap

The purpose of this chapter is to give an introduction to some of the properties of Tree-Adjoining Grammar (TAG: Joshi et al. 1975, Joshi & Schabes 1997, Abeillé & Rambow 2000, Joshi 2005; Kallmeyer 2010: ch. 4) and to draw some comparisons with Lexical Functional Grammar (LFG: Kaplan & Bresnan 1982, Bresnan et al. 2016, Dalrymple et al. 2019; Belyaev forthcoming(b) [this volume]). It is primarily aimed at those familiar with LFG who are looking to learn about TAG and see where the two formalisms differ/overlap, but the comparisons will also be of interest to those coming from a TAG background (although details of the LFG formalism will not be covered – the interested reader is directed to the references above and other chapters in this volume).

A TAG is a mathematical formalism for describing a set of trees, just as a context-free grammar (CFG) is a mathematical formalism for describing a set of strings. Unlike a CFG, which generates or recognises a string by repeatedly rewriting symbols until the target string is produced, a TAG does so by combining members from a starting set of ELEMENTARY TREES using two operations

Jamie Y. Findlay. Forthcoming. LFG and Tree Adjoining Grammar. In Mary Dalrymple (ed.), *Handbook of Lexical Functional Grammar*. Berlin: Language Science Press.

(called SUBSTITUTION and ADJUNCTION) until a tree whose yield is the target string is produced. This gives TAGs a greater generative capacity than CFGs, which is why they are of particular interest to researchers in natural language syntax: since Shieber (1985), we have known that the complexity of natural language syntax exceeds the context-free space which CFGs are capable of describing. In Section 2, I will briefly discuss this finding and the choice it has forced modern linguistic theories to make regarding their formal foundations. Section 4 delves more deeply into the generative power of TAG and compares it to LFG.

When TAG is used in a linguistic capacity, a number of properties are generally added to the basic formalism in order to better align it with certain theoretical assumptions and to enable more natural or transparent analyses of particular grammatical phenomena (e.g. the inclusion of feature structures on nodes to facilitate an analysis of agreement). In Section 3, I introduce some of the details of the TAG formalism along with these linguistically-motivated theoretical assumptions.

One important property generally assumed in linguistic applications of TAG is known as LEXICALISATION, the property whereby each of the basic structures of a grammar is associated with a single lexical item. Lexicalised grammars purportedly have a number of desirable traits, and I discuss lexicalisation in more detail in Section 5. This property sets TAG apart from CFG-based formalisms such as LFG, since the latter cannot in general be lexicalised – a perhaps surprising result given the lexical focus of LFG.

Section 6 briefly compares the TAG and LFG approaches to the factoring out of redundancies from grammars. TAG makes use of a so-called METAGRAMMAR, a formal system used to produce grammars, which can capture high-level generalisations and make grammar engineering easier. LFG uses TEMPLATES, which are part of the grammar proper, and allow pieces of linguistic description to be given names and reused.

Lastly, Section 7 considers the possibility of incorporating a TAG into the LFG architecture, replacing the standard CFG-based description of c-structure. This offers fertile new analytical possibilities, and has pleasing consequences for the descriptive power of LFG more generally, since it allows templates to be extended to the domain of phrase structure, opening the door to a fully constructional LFG.

2 Moving beyond context-free grammars

Context-free grammars have played (and continue to play) a major role in the development of syntactic theory at least since their formal elaboration in the 1950s

(Chomsky 1956), with their conceptual roots going back even further (at least to e.g. Harris 1946, Wells 1947). However, there was also always a sneaking suspicion that natural language syntax was formally more complex than CFGs could describe. Nevertheless, by the early '80s there had been no successful proof of this fact (Pullum & Gazdar 1982). In 1982, Bresnan et al. (1982) demonstrated that the presence of cross-serial dependencies means that the dependency structure of Dutch requires more than context-free power to describe, although owing to the lack of morphological marking of such dependencies, the *string* language of Dutch remains context free. It turns out, however, that Swiss German exhibits the same cross-serial dependencies, but its nouns are case-marked, and since different verbs can assign different cases to their objects, this means that the dependencies show up in the string language as well. Thus, greater-than-context-free power is definitely needed to describe Swiss German (Shieber 1985). Since there is no reason to suspect that speakers of Swiss German are biologically distinct from speakers of other languages, or that some people would be intrinsically unable to learn Swiss German as a first language, this means that the human language faculty generally allows for languages which require greater than context-free power to describe, and so CFGs alone are inadequate as the basis of a grammatical formalism.

Given this fact, there are two different kinds of response for the syntactic theorist. We can either

1. replace the CFG with something more powerful; or
2. beef up the CFG with something extra, so that the *combination* is more powerful.

Chomskyan generative grammar had already taken the second approach from the start: the addition of transformations to a CFG base pushes the formalism well beyond context-freeness, into the space of Type-0, unrestricted grammars (Peters & Ritchie 1973). LFG similarly adds something extra to the CFG component: in this case, a separate level of representation, f(unctional)-structure; the combination of the two takes the formalism as a whole at least into the Type-1, context-sensitive space (Berwick 1982 – although see Section 4).

However, in order to account for cross-serial dependencies, we do not need a full-blown context-sensitive (or even more powerful) grammar. Instead, we only need a more modest MILDLY CONTEXT-SENSITIVE grammar (Joshi 1985). Such grammars have the useful property, shared with context-free grammars, of being parsable in polynomial time, unlike the (worst case) exponential parsing time of context-sensitive grammars (Joshi & Yokomori 1983, Vijay-Shanker & Joshi 1985), though they still go beyond the expressive power of CFGs in permitting the description of cross-serial dependencies. Responses to the challenge of the non-context-freeness of natural language which take approach number 1 above, and replace the CFG wholesale, tend to do so with a formalism which is explicitly mildly context sensitive, therefore, rather than anything more powerful. One example of this is Combinatory Categorial Grammar (CCG: Steedman 1987, 2000); another is TAG.[1]

3 An introduction to TAG

A TAG is a tree rewriting system which consists of a set of ELEMENTARY TREES and the two operations of SUBSTITUTION and ADJUNCTION for combining them. Substitution simply inserts one tree at the frontier of another (at a non-terminal node), while adjunction inserts a tree *inside* another, attaching it at a non-frontier node (more formal definitions of these processes will be given below).[2]

Most linguistic work in TAG now assumes a LEXICALISED version, LTAG (Schabes et al. 1988), in which each tree is anchored by, i.e. has as its terminal node(s), a single lexical item (which may still consist of several words, as in the case of phrasal verbs, idioms, etc.). Similarly, while trees in a TAG (*qua* mathematical formalism) can be of any size, in linguistic applications the general principle applied is that trees should correspond to the EXTENDED MAXIMAL PROJECTION (Grimshaw 2000, 2005) of a lexical item, i.e. the syntactic projection which includes all functional heads and the full argument structure of the item. Some examples of elementary trees matching these restrictions are given in Table 1. In this chapter, I will use "TAG" to refer specifically to this sub-class of lexicalised,

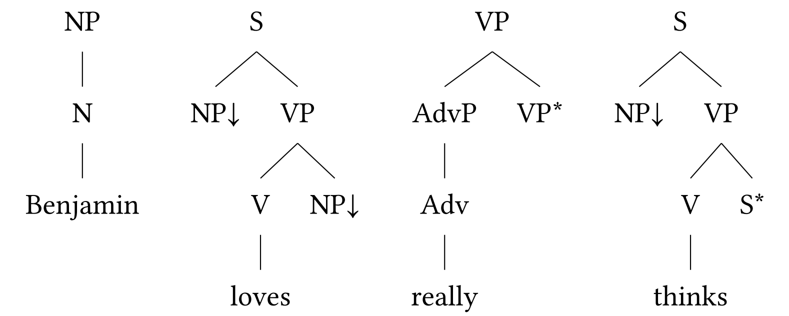
[1] In fact, things are a little more complex than this. In some definitions of mild context sensitivity (e.g. Kallmeyer 2010: 23–24), "permutation-complete" languages like MIX (the language consisting of the subset of $\{a, b, c\}^*$ with an equal number of *a*s, *b*s, and *c*s; see Bach 1981) are included (Salvati 2015, Nederhof 2016); in others (e.g. Joshi et al. 1991), they are not (Kanazawa & Salvati 2012). TAG and CCG are in the class which does not contain MIX, and so Steedman (2019: 415) suggests they should be called SLIGHTLY NON-CONTEXT-FREE to distinguish them from the larger class which does contain MIX. Nothing in this chapter hinges on this distinction, so I continue to use the more traditional "mildly context sensitive", without taking a position on whether or not this refers to the class of languages containing MIX or not.

[2] In the original formulation (Joshi et al. 1975), TAG only has one combining operation – adjunction. The addition of substitution, however, improves the descriptive capabilities of the framework, making it easier to use for linguistic purposes, while leaving its formal expressive power the same, since adjunction can be used to simulate substitution (Abeillé 1988: 7). In this chapter I will therefore continue to assume that both operations are used.

linguistically-constrained TAG rather than merely to the mathematical formalism, except where otherwise indicated.

Table 1: Some elementary trees

Initial trees	Auxiliary trees



Elementary trees come in two types. An initial tree is one where all of the frontier nodes are either terminals or non-terminals marked as substitution sites using the down arrow (↓).[3] Substitution sites indicate arguments of a predicate. An auxiliary tree is like an initial tree except that one of the frontier nodes, called the foot node, shares the same label as the root, and is marked with an asterisk (*). Auxiliary trees are combined with other trees via adjunction, to be described below. When two elementary trees have been combined, we have a derived tree, which can then be further manipulated just like an elementary tree.

In the next two subsections, I introduce the two operations used to combine trees in TAG: substitution and adjunction.

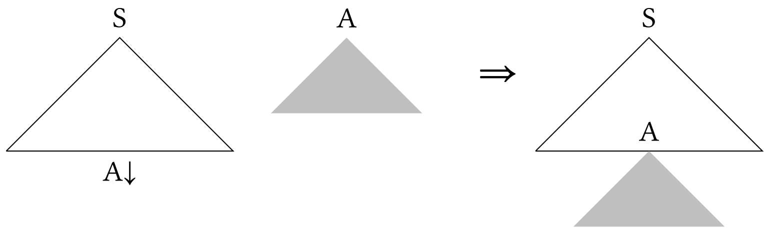
3.1 Substitution

When the root of a tree has a label which matches that of a non-terminal frontier node in another tree, the first tree can be inserted at that frontier node in the second; this is called substitution, and is the process normally used to combine a predicate and its arguments. Example (1) shows this process schematically, while

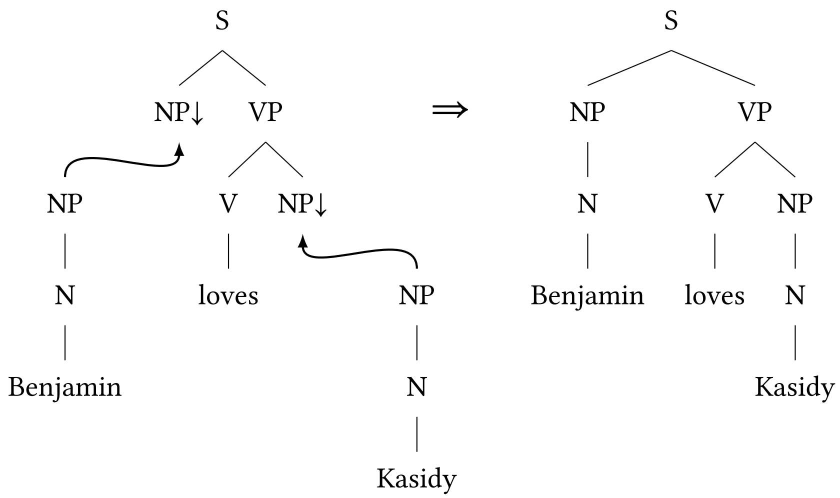
[3]As can be seen from this definition, every non-terminal frontier node is a substitution site, so the ↓-annotation is formally redundant. Nevertheless, it is often included in expository text (if not in computational implementation) to make it clear at a glance that a tree does not represent a fully completed derivation.

(2) gives a linguistic example involving two cases of substitution: the derivation for *Benjamin loves Kasidy.*

(1) **Substitution** (after Abeillé & Rambow 2000: 5)



(2)

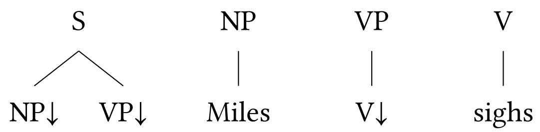


A tree rewriting grammar which makes use of substitution alone is called a Tree Substitution Grammar (TSG), and is at least weakly equivalent to a CFG – that is, such grammars describe the same set of string languages (weak equivalence), although there are some tree languages which which can be described by a TSG for which an equivalent CFG does not exist (so strong equivalence is not guaranteed).[4] This is easy to see if we imagine converting a CFG into a TSG:

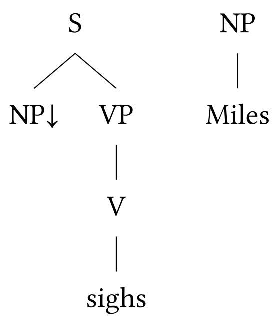
[4]Any CFG can easily be converted into a TSG by simply turning each phrase-structure rule into a tree rooted in the left-hand symbol with the right-hand symbols as daughters, as will be illustrated in the text. But to convert a TSG into a CFG, it may be necessary to relabel some nodes, since the dependency between a mother and its daughters may be tree-specific, and so not hold generally (for example, it might be the case that only trees anchored by transitive verbs have a VP dominating both a V and an NP node) – so the CFG might have to have more non-terminal symbols than the TSG (e.g. $\mathrm{VP}_{\mathrm{trans}}$ and $\mathrm{VP}_{\mathrm{intrans}}$ instead of just VP).

all we do is replace each phrase-structure rule with the equivalent tree which it describes (cf. McCawley's 1968 conception of phrase-structure rules as node admissibility conditions, i.e. descriptions of trees). For example, the CFG in (3) corresponds to the TSG in (4):

(3)
S	$\longrightarrow$	NP VP
NP	$\longrightarrow$	Miles
VP	$\longrightarrow$	V
V	$\longrightarrow$	sighs

(4)


Although TSGs and CFGs are formally very close (at least weakly equivalent), there is an important theoretical difference between them: TSGs have an EXTENDED DOMAIN OF LOCALITY with respect to CFGs. Every rule in a CFG describes a tree of depth 1, but trees in a TSG can be of arbitrarily large size, which means that certain grammatical dependencies, like agreement or extraction, can be described locally in a TSG (i.e. in a single elementary tree) when they cannot be in a CFG (i.e. they cannot be described in a single rule). For example, the TSG in (5) is equivalent to that in (4), except that now the verb and its subject are in the same elementary tree, and so the agreement relationship between the two could be described locally.

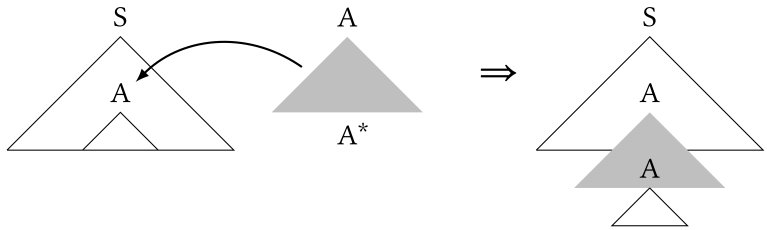
(5)


Many possibilities exist as to *how* to describe such a dependency – for example, by using complex categories in the style of GPSG (on which see Gazdar et al. 1985), or by using feature structures (on which see Section 3.3); but the point is that however one chooses to represent this relationship, it can be described locally in a TSG when it can only be described indirectly in a CFG, e.g. by percolating features up from V to VP, thus making them visible to the S → NP VP rule which introduces the subject.

3.2 Adjunction

If we add adjunction, a second type of combining operation, to a TSG, we obtain a TAG. While substitution allows a tree to be inserted at a frontier node of another tree, adjunction allows insertion at a *non*-frontier node: the adjoining tree expands the target node around itself. A tree which adjoins into another tree, called an auxiliary tree, must therefore have at least one frontier node with the same label as its root – this is called the foot node. The process of adjunction is represented schematically in (6):

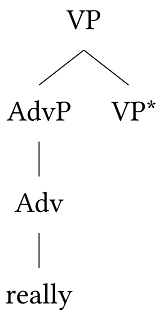
(6) **Adjunction** (after Abeillé & Rambow 2000: 9)



Because of the requirement that the root and foot of an auxiliary tree have the same label, such trees can be seen as factoring recursion out of the grammar. Rather than having a cyclic path through the rewrite rules (as in a CFG), we have a tree which directly encodes such a cycle (in (6), an A contained within an A), which can then be added into a structure via adjunction. For this reason, such auxiliary trees are used to model the recursive aspects of natural language syntax – most notably modification and sentential embedding.

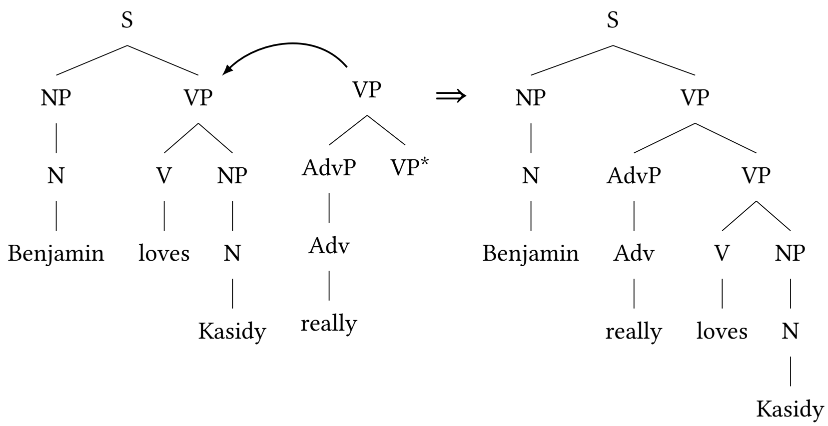
Modifiers such as adjectives and adverbs, but also e.g. relative clauses, are represented as auxiliary trees. For example, *really* is a VP-adverb which appears to the left of the VP it modifies, and so is represented by the following tree:

(7)



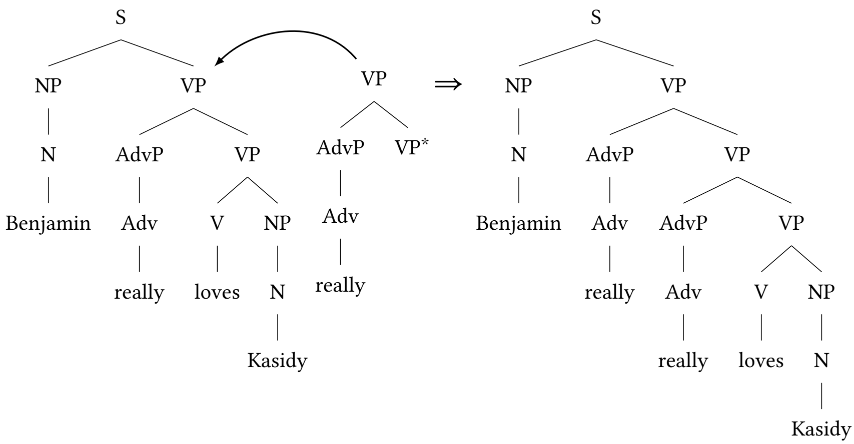
To see this in use, consider the derivation for the sentence *Benjamin really loves Kasidy*: after the substitutions shown above in (2) to generate *Benjamin loves Kassidy*, we can then adjoin the tree from (7) at the VP node in the clause:

(8)



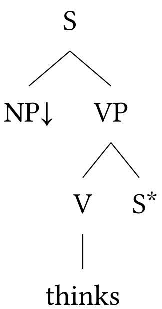
Of course, such a process can be repeated indefinitely many times, since there is always still a tree-internal VP node available to be adjoined to:

(9)



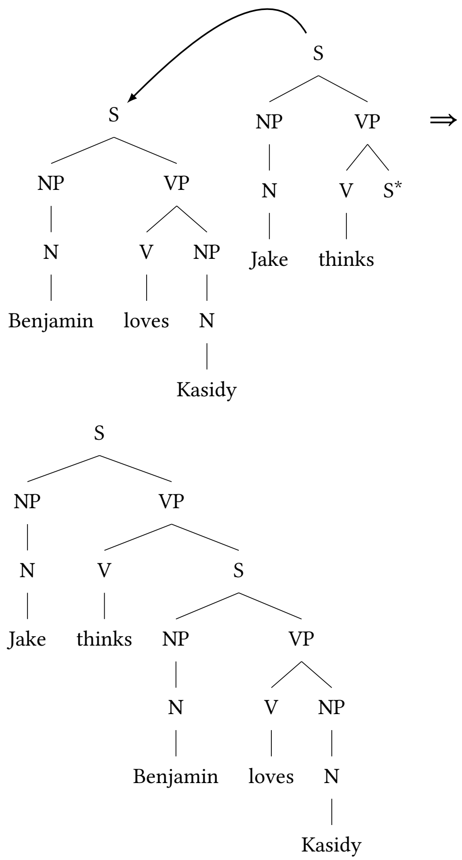
This accounts for the iterability of modifiers like *really*.

Another, perhaps more theoretically interesting, area of recursion in the grammar is in the domain of subordination, i.e. sentential embedding. Verbs which take sentential complements are represented as auxiliary trees, as in (10), for example:

(10)


Notice that this means that sentential arguments are treated rather differently from other arguments in TAG: while arguments are normally combined with their governors by means of the former being substituted into the latter, sentential arguments combine with their governors by means of the latter being adjoined into the former – this is shown in (11).

(11)

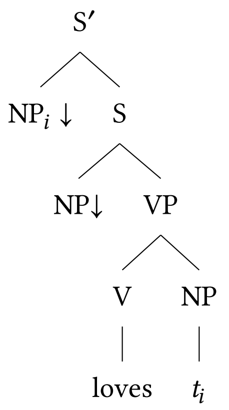


For simple declarative sentences this is a rather unnecessary complication, since the same effect could be achieved by making the foot node of the sentential-embedding verb a substitution site instead. However, the factoring of recursion into auxiliary trees interacts with another TAG principle – the local representation of syntactic dependencies. Owing to their extended domain of locality, it is possible to represnt many kinds of syntactic dependencies locally (i.e. in a single elementary structure) in TAG that would require some additional mechanism in other frameworks. This principle extends to filler-gap relations as well, such as that between a fronted focus phrase and its verbal governor, as in (12):

(12) *Kassidy* Benjamin loves (whereas Kira he merely likes).

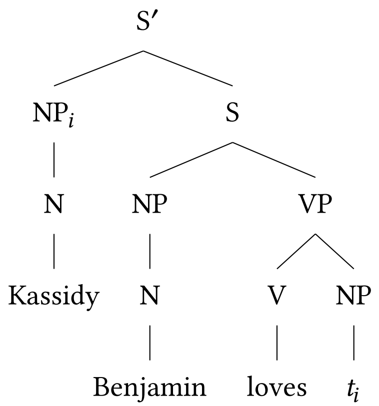
The tree in (13) represents the appropriate form of the verb *loves*, with its object extracted:[5]

(13)



Through substitution alone, this can be used to derive (14):

(14)



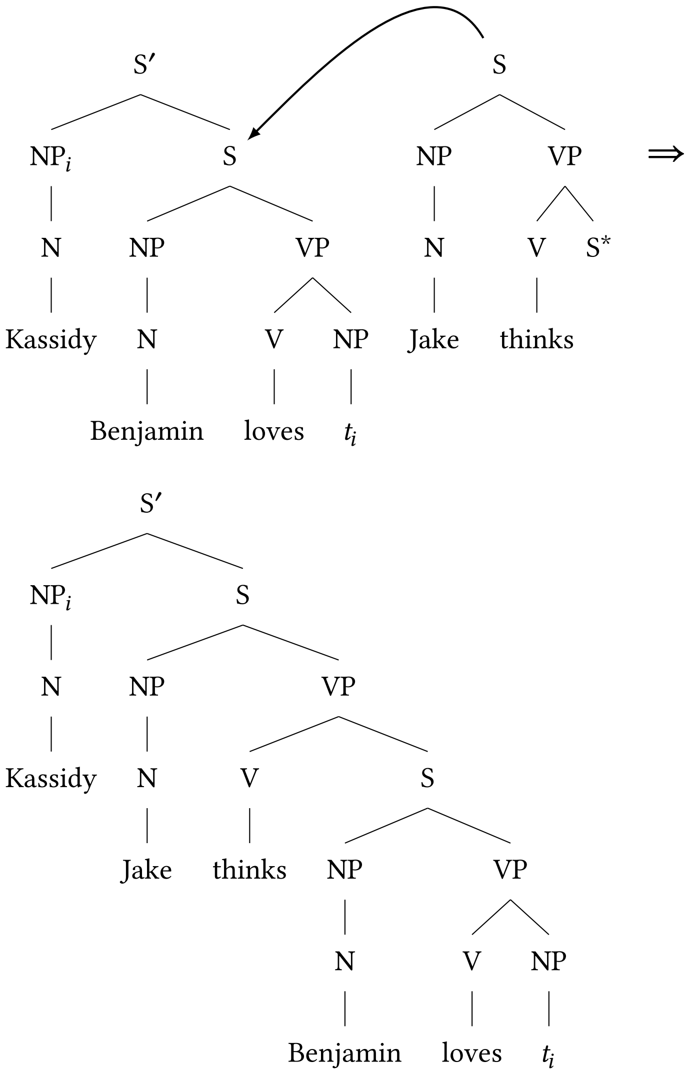
But of course the distance between the fronted phrase and the gap can span multiple clauses, and can be arbitrarily large:

(15) *Kassidy* [Jadzia knows [Jake thinks … [Benjamin loves]]].

[5]The use of a trace in object position here is not an essential part of the TAG analysis, though in practice it is common. One reason for this, as argued for by Kroch (1987) and Kroch & Joshi (1985), is that empty elements allow for easier specification of some constraints on extraction in terms of the topology of trees, rather than necessitating additional mechanisms, like functional uncertainty and off-path constraints in LFG. A reviewer points out that traces are also useful in the metagrammar (see Section 6 on this concept), since they allow tree fragments to be reused more easily.

Since sentential embedding verbs are treated as auxiliary trees, this poses no problem – they are adjoined to the internal S node, and thus extend the distance between the gap and the filler:

(16)



What is more, this can clearly be repeated: other trees can be adjoined at the topmost S node, further increasing the distance between the filler and the gap. Thus, a potentially quite radically non-local dependency, between the fronted expression and its governing verb, can be expressed locally in the grammar, in a single elementary tree, because the operation of adjunction allows for the distance between nodes in a tree to grow over the course of a derivation. This same process can be applied to other kinds of filler-gap dependencies, such as *wh*-questions and relative clauses, though for ease of exposition I have chosen not to illustrate these here (since for these we must also account for things like subject-auxiliary inversion and *do*-support).[6] The TAG approach is in contrast to that of many other syntactic theories which instead derive or infer the relation between filler and gap via some additional syntactic mechanism, be that movement or, in the case of LFG, a functional uncertainty path.

3.3 Expressing constraints

Adjunction of an auxiliary tree, which has a root and foot node with the same label, captures the effects of recursion in other formalisms. However, once an auxiliary tree has been adjoined in, there will be two nodes with the same label where there was previously just one. This means that if we adjoin the same tree again (e.g. as in (9), where we adjoin *really* twice), there are two distinct possible targets (and after that adjunction there will be three, etc.). This has the potential to dramatically complicate parsing, since there will be multiple distinct possible derivations for the same tree (without there also being a genuine ambiguity of interpretation), and so we would like a means of controlling where adjunction takes place. TAG originally did this by using local constraints on adjunction (Joshi 1987: 100ff.), annotations added to the nodes of elementary trees indicating which auxiliary trees can be adjoined there. If the list of adjoiners is empty, we have a NULL ADJUNCTION (NA) constraint, which prohibits adjunction at the node. If the list is non-empty, then we have a SELETIVE ADJUNCTION (SA) constraint, which limits the trees which can adjoin. There are also OBLIGATORY ADJUNCTION (OA) constraints, which are like SA constraints except that one of the listed trees *must* be adjoined at the annotated node. In classic TAG, this is achieved simply by a diacritic indicating that the constraint is an OA one rather than an SA one. We will see below how this can be achieved in a less stipulative way by making use of feature structures.

Using these constraints, we can avoid having multiple possible parses for sentences by marking the foot node of auxiliary trees with an NA constraint (as is done in the XTAG grammar of English, for example – XTAG Research Group

[6]The interested reader should consult the detailed analyses of these and other constructions in English provided by the XTAG project (XTAG Research Group 2001).

2001). This means we do not add an extra potential target for adjunction each time such a tree is adjoined in, since only the root of the auxiliary tree is available for further adjunction.

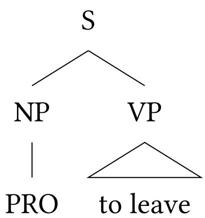
In addition to this practical motivation, adjunction constraints play a crucial theoretical role: they are a vital part of what makes TAG mildly context sensitive. Without adjunction constraints, the formalism is still more powerful than a CFG, but there are several mildly context-sensitive languages which it cannot express, such as the copy language $\{ww \mid w \in \Sigma^*\}$, or the language $\{a^n b^n c^n \mid n \geq 0\}$, also called COUNT-3 (Kallmeyer 2010: 27, 58; we return to COUNT-3 in Section 4).

Let us now consider an example illustrating the other two kinds of constraints, which shows their use in linguistic theorising. Vijay-Shanker (1987: 134–135) considers non-finite sentential complements such as (17):

(17) John tried [PRO to leave].

Assuming the subordinate clause has the tree in (18), our analysis needs to do two things: ensure that such clauses cannot appear on their own as full sentences – cf. (19) – and ensure that they can be embedded only under verbs that select for infinitival forms – cf. (20).

(18)



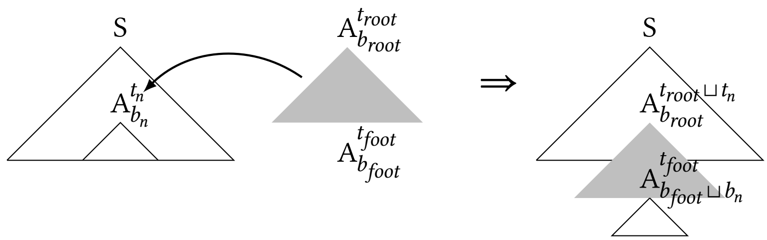
(19) *To leave.

(20) a. John tried to leave.
b. *John imagined to leave.

In other words, *something* must be adjoined into the root node S (an OA constraint), and that something must only be a sentential embedding verb that selects for a non-finite complement clause (an SA constraint).

Originally, these constraints were simply seen as listings of (permitted/required) auxiliary trees, but this is not particularly linguistically illuminating, and also difficult to maintain for a grammar writer. This is remedied in later TAG work through the use of feature structures. It is common to associate nodes with feature structures in CFG-based grammars (e.g. in GPSG – Gazdar et al. 1985) in order to represent grammatical features such as case, number, tense, etc. Indeed, this is what LFG's f-structures do too (although there multiple structures from different nodes are merged into one). However, in a TAG, we cannot guarantee the integrity of each node in the tree: through adjunction, it may be split up into two nodes, corresponding to the root and foot nodes of an auxiliary tree. For this reason, in feature structure-based TAG (FTAG: Vijay-Shanker 1987: ch. 5; Vijay-Shanker & Joshi 1988), each node is associated with a *pair* of feature structures, called the TOP and BOTTOM feature structures. The top features refer to the relation of the node to its siblings and its ancestors, i.e. the view from above the node in a tree. The bottom features refer to its relation to its descendants, i.e. the view from below (Vijay-Shanker 1987: 129). Ultimately, the top and bottom features of a node must unify, to give a single description of the properties of that node. However, during the course of a derivation, adjunction may split up the node so that it is now two nodes instead; in that case, its top features will be unified with the top features of the root of the auxiliary tree involved, and its bottom features will be unified with the bottom features of the auxiliary tree's foot node. This is shown schematically in (21):

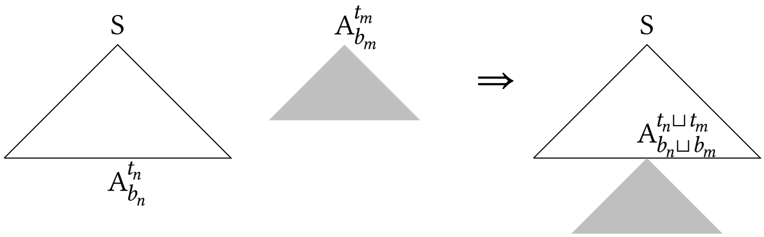
(21) **Adjunction in FTAG** (after Vijay-Shanker 1987: 130)



Substitution is simpler, since the root node of the substituted tree is simply identified with the substitution site, and so both top and bottom feature structures unify:[7]

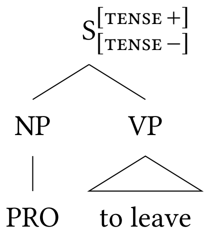
(22) **Substitution in FTAG**

[7]The diagram in (22) follows Vijay-Shanker's (1987) original formulation, where substitution sites also contain bottom features. In much other work using FTAG, this is not the case, so b_n in (22) would be absent, and the final bottom features of A in the derived tree would simply be b_m (XTAG Research Group 2001: 13). This is of course equivalent to (22) with b_n instantiated as the empty set.



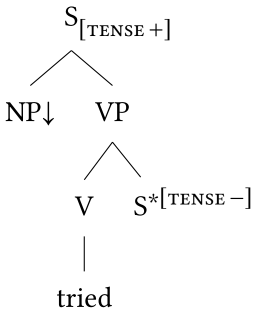
These feature structures can be used to enforce various linguistic constraints. For example, we can enforce subject agreement in initial trees for verbs by specifying number and person features on the subject NP position. More interestingly, we can use features to account for the constraints on adjunction discussed above. Because the features associated with whatever tree is adjoined at a node have to unify appropriately with its top and bottom features, we can control which trees are compatible by giving them (mis)matching features which make unification possible or not. What is more, we can give a more principled account of obligatory adjunction constraints by making the top and bottom features of a particular node incompatible with one another. This means that unless adjunction takes place and the node is split up, unification will be impossible, and the derivation will fail. Returning to our example from above, here is the tree from (18) with two added feature annotations:

(23)

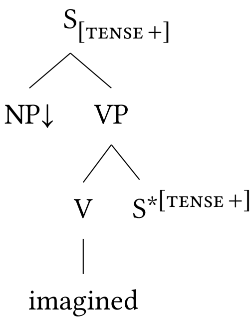


Since these features are incompatible and cannot unify, we have achieved the first of our goals, which is to ensure that this tree cannot appear on its own – i.e., to implement an OA constraint. Owing to the feature mismatch, this tree is illicit unless something adjoins to the root node. To achieve the SA constraint, we need to consider the elementary trees of verbs like *tried* and *imagined*. Here we present them with just the relevant features added:

(24)

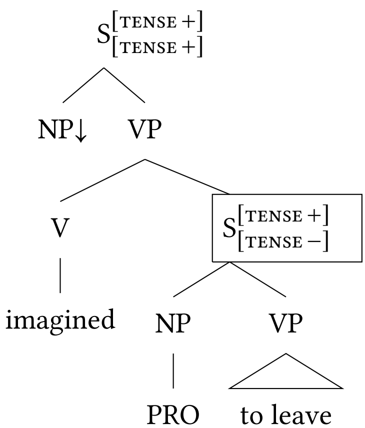


(25)



The difference between the two verbs is that *tried* selects for a non-finite, untensed, complement clause, whereas *imagined* selects for a tensed one – this is indicated by the top features on their foot nodes. If we attempt to adjoin *imagined* into the tree for the subordinate clause in (23), then we end up with mismatching features on the foot node, which means they cannot unify, and the tree remains illicit:

(26)



If we adjoin the tree for *tried*, however, then there is no mismatch, and the derivation succeeds.

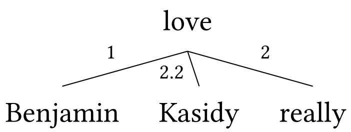
If we allow a fully-fledged unification-based feature system in FTAG, with recursive feature structures of potentially unbounded size, then FTAG becomes undecidable (Vijay-Shanker 1987: 155f.). This is a very bad result given the emphasis that TAG places on tractable, polynomial parsing. For this reason, the feature structures in FTAG are more restricted, and do not permit recursion/re-entrancy, which makes them quite unlike LFG's f-structures.

3.4 Derivation trees and dependencies

In a CFG as classically conceived, the familiar phrase-structure tree is in fact a representation of the derivation, i.e. of the process by which the output, namely the string, was produced. TAGs also have these DERIVATION TREES, representing the way in which trees were combined during a derivation – but, of course, in a TAG, the output of the derivation is already a tree, called the "derived tree" to set it apart. The derived tree represents word order, constituency, and category information, like LFG's c-structure. So what linguistic information does a TAG derivation tree encode? Since each elementary tree in a (lexicalised) TAG corresponds to a lexical item, the derivation tree actually represents relations between lexical items, and so has much in common with a dependency grammar representation of the sort illustrated by Meaning-Text Theory (Mel'čuk 1988), the more contemporary Universal Dependencies project (UD: Nivre et al. 2016), or, indeed, an LFG f-structure (on the relationship between dependency grammars and LFG, see also Haug forthcoming(b) [this volume]).

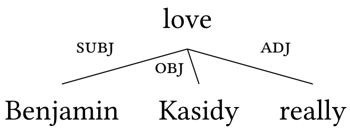
A derivation tree for *Benjamin really loves Kasidy*, the derivation for which was shown in (2) and (8), is given in (27) (cf. Joshi & Schabes 1997: 74ff.):

(27)



Here nodes are labelled with the lexeme corresponding to the elementary tree in question. Whenever a tree is substituted or adjoined into another tree, it becomes its daughter in the derivation tree. The derivation tree in (27) shows that three trees, corresponding to *Benjamin*, *Kasidy*, and *really*, were combined with the tree for *love*. Each edge is also labelled, standardly with a node address which indicates where the tree was substituted or adjoined.[8] However, we can equally well use different labels, such as assigning grammatical function names to argument positions and then treating other positions as ADJ (cf. Rambow & Joshi 1997: 175). This would give us the following derivation tree instead of (27), making the parallel with dependency structures quite explicit:

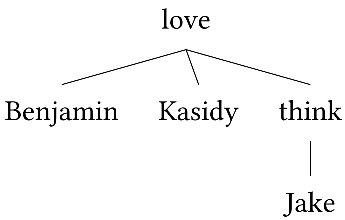
(28)



Rambow & Joshi (1997) discuss the relationship between TAG and dependency grammars in more detail.

Unfortunately, the TAG treatment of sentential embedding somewhat undermines the neat parallel between derivation trees and dependency structures (Rambow et al. 1995, 2001). Recall that arguments are normally substituted into their governors, but that clausal complements have their governors adjoined into them. This reverses the normal dependency relations, and means that "(standard) LTAG derivation trees do *not* provide a direct representation of the dependencies between the words of the sentence, i.e., of the predicate-argument and modification structure" (Rambow et al. 2001: 117, emphasis in original). To see why this is so, consider the derivation tree for (11), *Jake thinks Benjamin loves Kasidy*:

(29)



Here *think* is a dependent of *love*, because the *think* tree is adjoined into the *love* tree, when of course in any real dependency grammar the relation would be reversed:

[8] These are so-called GORN ADDRESSES (Gorn 1967). The root has the address 0 (or sometimes ϵ, i.e. the empty string), the kth child of the root (reading left-to-right) has the address k, and for all other nodes, the qth child of a node with address p has the address $p.q$ (Joshi & Schabes 1997: 75).

(30) think
- Jake
- love
  - Benjamin
  - Kasidy

There are technical means of handling this unhappy result (see e.g. Joshi & Vijay-Shanker 2001, Kallmeyer & Kuhlmann 2012), but it nevertheless makes the parallel with dependency structures rather less direct. All the same, we might be tempted to see the division of labour between derived trees and derivation trees in TAG as analogous to that between c-structure and f-structure in LFG, where the former represents constituency, word order, and category information, and the latter encodes a sentence's dependency structure. This is certainly true to a point, but the parallel is imperfect, because f-structure also represents other information beyond the dependency structure of a sentence – syntatic features like person, number, tense, aspect, etc., which in TAG are encoded in the feature structures associated with each node instead. Still, one thing that derivation trees and f-structures have in common is that they are both seen as the appropriate level of representation to serve as input to the semantic component of the grammar.

3.5 Semantics

There have been a variety of different proposals for interfacing TAG with a semantic theory, and space precludes a full presentation here. Nonetheless, I give a superficial overview here so that the interested reader can investigate further.

An early proposal for doing semantics with TAG makes use of Synchronous TAG (STAG: Shieber & Schabes 1990). In STAG, elementary trees from one grammar are paired with those from another, and links are established between individual nodes in those trees. Then, when adjunction or substitution applies in one grammar, it must also take place in the other, at the linked node, and using the equivalent, paired tree. By pairing a TAG grammar with a tree-based semantic representation, we can therefore implement a "rule-to-rule" approach to semantic derivation (to use Bach's 1976 terminology).[9] Nothing requires the paired trees to be isomorphic, so on the syntactic side it is the structure of the derivation tree,

[9] Alternatively, by pairing two TAG grammars from different languages, we can implement a machine translation system – see Abeillé et al. (1990).

not the derived tree, which determines the meaning. Although this approach has largely fallen out of favour in TAG circles, see Nesson & Shieber (2006, 2007, 2008) for a modern revival.

Another approach which uses the derivation tree as the basis for semantic interpretation is that of Joshi & Vijay-Shanker (2001). Here elementary trees are associated with triples of semantic expressions, the first of which specifies the main variable of the predication, the second of which gives the predicate with its arguments, and the third of which specifies which argument variables are associated with which nodes in the tree. When a tree is substituted into another tree, its main variable is identified with the corresponding argument variable in the target tree's semantics (special consideration has to be made for adjunction, as discussed above: the order of dominance in the derivation tree will be different for sentential vs. non-sentential complements – see Joshi & Vijay-Shanker 2001: 152f.). Since this makes use of a unification-based semantics, the order of combination of the elementary trees is irrelevant, and the derivation tree thus offers an appropriate level of representation, since it abstracts away from order, and simply says how and where trees were combined. This unification-based approach has been developed more recently by Laura Kallmeyer and colleagues, introducing a new focus on underspefication (Gardent & Kallmeyer 2003, Kallmeyer & Joshi 2003, Kallmeyer & Romero 2004, 2008). This has also been integrated with Frame Semantics (Kallmeyer & Osswald 2013).

In LFG the *de facto* standard approach to the syntax-semantics interface is Glue Semantics (Asudeh forthcoming [this volume]). Observing that, for example, the operation of function application as used in natural language semantics is order insensitive, and that quantifier scope ambiguities show that semantic interpretation does not (always) respect the constituent structure of a sentence (see Asudeh 2012: ch. 5), Glue rejects c-structure as the appropriate level of input to semantics, and uses (a projection of) f-structure instead (where order is irrelevant and many c-structure hierarchies are collapsed). Thus, as in TAG, it is the dependency structure, not the phrasal structure, which is taken as relevant for semantic interpretation.

Interestingly, however, one of the only examples of TAG theorists criticising the derivation-tree-based approach to semantic interpretation is when Glue Semantics has been combined with TAG (Frank & van Genabith 2001). Frank & van Genabith argue, mostly on the basis that, as discussed above, it provides the wrong dependency structure, that the derivation tree is not suitable as the input to semantic interpretation, and they instead make use of the derived tree in their Glue-based framework.

3.6 The big picture

Linguistic theories based on TAG have two key properties (Joshi & Schabes 1997: 95f.):

1. Extended domain of locality: Since TAG elementary trees encompass the whole extended projection of a lexical item, dependencies which in a simple CFG-based grammar would be spread across multiple rules, e.g. agreement, can be expressed "locally" in a TAG (i.e. in the same elementary structure). This is what enables a TAG to lexicalise a CFG (see Section 5).

2. Factoring recursion from the domain of dependencies: Relatedly, the elementary trees are the structures over which the vast majority of dependencies are stated, and that includes filler-gap relations. Such dependencies are therefore local in nature, but can become long distance via the adjunction operation. Recursion is thereby factored out of the domain over which these dependencies are initially stated.

This approach is summed up by Bangalore & Joshi (2010: 2) in the slogan "complicate locally, simplify globally". That is, local, elementary representations are where almost all linguistic constraints are stated, meaning that they can become quite complex, but the payoff is that the composition of elementary trees can be achieved by just two, very general, operations: substitution and adjunction. This also means that cross-linguistic variation is entirely a matter of what elementary trees a grammar contains, a position very much in keeping what Baker (2008: 353) calls the Borer-Chomsky Conjecture, after Borer's (1984) proposal and Chomsky's (1995) later adoption of it, whereby parametric variation is restricted to the lexicon.

How does this compare with LFG? The second property certainly divides the frameworks: LFG grammars include recursive c-structure rules, and filler-gap dependencies are expressed syntactically, not lexically. This means, moreover, that the lexicon is not the only source of complexity in LFG grammars; many constructions are analysed as instantiating complex annotated phrase structure rules (see e.g. the analysis of long-distance dependencies in Dalrymple 2001: ch. 14). There is more overlap between the two frameworks when it comes to the first property. Via the parallel projection architecture (see Belyaev forthcoming(b): sec. 5 [this volume]), LFG does obtain an extended domain of locality: for example, agreement can be encoded locally in the agreement controller's lexical entry via the use of paths through f-structure (see Haug forthcoming(a) [this volume]). However, since c-structure is generated by a CFG, any non-local dependencies between c-structure nodes (i.e. those spanning more than one "generation" in the tree) can only be expressed indirectly via other levels of representation. That is, we have no extended domain of locality at c-structure *per se*, only parasitically via other levels. To the extent that phrasal constructions larger than a tree of depth 1 are objects we want to be able to represent in the grammar, this is a shortcoming. We return to this point in Section 7.2.

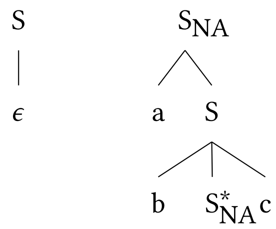
Construction Grammar (CxG: Fillmore et al. 1988, Goldberg 1995, 2006, Kay & Fillmore 1999, Boas & Sag 2012, Hoffmann & Trousdale 2013, *i.a.*) of course considers such objects as basic to linguistic theorising, and for this reason it has been argued that TAG is a natural means of formalising CxG (Lichte & Kallmeyer 2017). For example, among the properties of constructions listed by Fillmore et al. (1988: 501), one is that they "need not be limited to a mother and her daughters, but may span wider ranges of the sentential tree" – precisely the enlarged definition of locality which a TAG provides, and which LFG denies (at least directly). TAG has a natural means of representing both "formal" and "substantive" idioms, to use Fillmore et al.'s classification: formal idioms can be included in the set of trees associated with each lexical item of the appropriate class (Lichte & Kallmeyer 2017: 208f.), and substantive idioms can be represented as elementary trees in their own right (Abeillé 1995). While LFG can quite well represent formal idioms at the more schematic end of the scale (see e.g. Asudeh et al. 2013), it struggles with substantive idioms, precisely because it lacks an extended domain of locality at c-structure (Findlay 2022: sec. 4).

4 Generative capacity

TAG was designed specifically as a formalism with only mildly context-sensitive power (in the technical sense of Joshi 1985). This means there are languages out of the reach of context-free grammars that TAGs can describe, but also that there are languages properly considered context sensitive which TAG cannot. Such a constrained expansion into the context-sensitive space enables parsing algorithms for TAG to preserve the computationally appealing property of a polynomial run time.

As a simple demonstration of the increased generative capacity of a TAG when compared to a CFG, consider the artificial formal language $\{a^n b^n c^n \mid n \geq 0\}$, also known as count-3 – that is, the language which contains all strings consisting of some number of *a*s followed by the same number of *b*s, then the same number of *c*s. Partee et al. (1990: 497) demonstrate through application of the pumping lemma for context-free languages that count-3 is not context free. By contrast, there is a quite straightforward TAG grammar for COUNT-3, shown in (31):[10]

(31)



So, we can see that TAGs are more powerful than CFGs. They are not, however, very much more powerful. There are many kinds of language which they cannot describe, including those which it has been shown can be described by similarly modest extensions to context-free grammars. One example of this is the language MIX (Bach 1981), mentioned in footnote 1, which consists of all permutations of each string in the set $\{a^n b^n c^n \mid n \geq 0\}$, i.e. any number of *a*s, *b*s, and *c*s, in any order, provided there is the same number of each. Salvati (2015 – originally circulated as a technical report in 2011) showed that MIX is in the class of multiple context-free languages, where a multiple context-free grammar (MCFG) is itself a mildly context-sensitive grammar formalism, for which the parsing problem is also decidable in polynomial time. However, MIX is *not* a tree-adjoining language, as conjectured by Joshi et al. (1991) and proved by Kanazawa & Salvati (2012): so there are languages which are only slightly within the context-sensitive space and which are still not describable by a TAG. More generally, although COUNT-3 and COUNT-4 (i.e. $\{a^n b^n c^n d^n \mid n \geq 0\}$) are tree-adjoining languages, COUNT-5 is not (Joshi 1985: 223f.).

The carefully constrained computational complexity of TAG is in marked contrast to the situation in LFG (although see below for attempts to constrain the power of the LFG formalism). Whereas the class of tree-adjoining languages is equivalent to that of the mildly context-sensitive languages (or, perhaps, the slightly non-context-free languages: see fn. 1), the languages described by LFGs are equivalent to the class of recursively enumerable languages (Nakanishi et al. 1992). This has the expected deleterious effect on computational complexity: the parsing problem for LFGs is NP-complete (Berwick 1982), and so, in the worst case scenario, computationally intractable (assuming P ≠ NP).

There have been attempts to remedy this situation, however. While the LFG formalism as a whole may be computationally very complex, some of the properties responsible for this are not relevant for the description of natural languages

[10] Recall that a node annotated with "NA" bears a null adjunction constraint – see Section 3.3. As mentioned above, without adjunction constraints, TAG becomes less expressive, and cannot describe COUNT-3: see Kallmeyer (2010: 222) for a proof.

– this opens the possibility that the formalism could be constrained to allow tractable parsing (i.e. in polynomial time) while still preserving its usefulness as a tool for describing natural languages. Seki et al. (1993) propose one such restriction, which limits the kinds of functional annotations permitted on c-structure nodes, and the number of nodes which can correspond to a single f-structure. This successfully buys tractability for the resulting formalism, but at a heavy theoretical cost: many staple aspects of LFG analyses are no longer available, including the very common ↑ = ↓ head-sharing annotation, or functional control equations like (↑ XCOMP SUBJ) = (↑ SUBJ). More recently, Wedekind & Kaplan (2020) have addressed this limitation, describing a more expressive but still tractable version of the LFG formalism, which is provably equivalent to a Linear Context-Free Rewriting System (LCFRS), and therefore in the mildly context-sensitive space. (See also Kaplan & Wedekind forthcoming [this volume] and references therein for discussion of the formal and computational properties of LFG.) This approach only covers the original LFG formalism of Kaplan & Bresnan (1982), however, and it remains to be seen whether certain extensions to this basic formalism, such as functional uncertainty (Kaplan et al. 1987, Kaplan & Zaenen 1989), can be accommodated as straightforwardly in this new approach.

One point worth noting is that even in the absence of a tractable version of LFG, this contrast between TAG and LFG should not automatically be viewed as a failing on the part of the latter. In fact, it reflects a rather deep meta-theoretical question: do we want the formalism *itself* to say something interesting about the class of natural languages? The view embodied by TAG (and CCG, MCFG, etc.) is that we should be interested in “finding a grammar formalism that, by itself, gives already a close characterization of the class of natural languages” (Kallmeyer 2010: 7). By contrast, the view embodied by LFG (and HPSG, Minimalism, etc.) is that “it is the theory that imposes the constraints, not the language in which the theory is expressed” (Pollard 1997: 9). In theoretical terms, at least, it does not seem obvious that one approach is *better* than the other – they are merely different perspectives on the problem.[11]

[11]Of course, from a more practical point of view, it matters very much whether a formalism is tractable if it is to be used in some natural language processing task. However, there is already a very successful computational implementation of LFG in the form of the Xerox Linguistic Environment (XLE: Kaplan & Newman 1997; Crouch et al. 2011), which employs various “packed computation” (Lev 2007) heuristics to ensure efficient parsing (Maxwell & Kaplan 1989, 1993, 1996). So whatever limitations may exist in principle, they do not necessarily apply in practice.

5 Lexicalisation

I mentioned at the start of Section 3 that linguistic applications of TAG assume that the grammar is "lexicalised". Abeillé & Rambow (2000: 7) give the following definition of this term (emphasis in original):

> We will call a grammar *lexicalised* if every elementary structure is associated with exactly one lexical item (which can consist of several words), and if every lexical item of the language is associated with a finite set of elementary structures in the grammar.

In contrast to (L)TAG, LFG grammars are not in general lexicalised, which is perhaps somewhat surprising given what the "L" in "LFG" stands for. Although there is a focus in LFG on the lexicon as a richly structured respository of grammatical information, there is no requirement that this information *cannot* be expressed through non-lexical means. This section begins by sketching the potential for lexicalising CFG-based formalisms, like LFG, and then explores what the potential advantages of lexicalised grammars are.

In general, CFGs are not lexicalised. For example, the toy grammar in (3), repeated below, is not lexicalised, since the first and third rules are not associated with any lexical item – they consist purely of non-terminals.

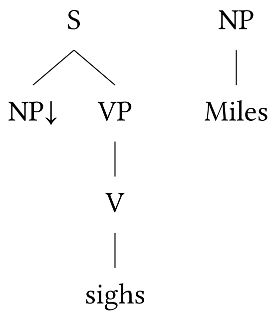
(3)
S	$\longrightarrow$	NP VP
NP	$\longrightarrow$	Miles
VP	$\longrightarrow$	V
V	$\longrightarrow$	sighs

Since LFG is based on a CFG, via c-structure, LFG grammars standardly make use of many non-lexicalised rules like these, which means that LFG grammars are generally not lexicalised.

It is possible to convert a non-lexicalised grammar into a lexicalised one, but this can require a change to the formalism used. We can speak of one grammar (weakly or strongly) LEXICALISING another if the former is (weakly or strongly) equivalent to the latter, except that the former is lexicalised whereas the latter is not.[12] For example, the Tree Substitution Grammar shown above in (5), and repeated below, STRONGLY LEXICALISES the grammar in (3), since each elementary object in (5) is associated with a lexical item, and the grammar describes the same string and tree language as (3).

[12]Two (classes of) grammars are weakly equivalent if they describe the same (sets) of string languages (though the corresponding (sets of) tree languages may differ). They are strongly equivalent if they also describe the same (sets) of tree languages.

(5)



Sometimes it is possible to use a CFG to strongly lexicalise another CFG, but it turns out that this cannot be guaranteed in principle. For, although there is a way of converting any CFG into so-called Greibach normal form (Greibach 1965), where the right-hand side of each rule begins with a terminal symbol – thereby lexicalising the grammar – such grammars do not in general generate the same set of trees as the grammars they normalise, since they will include different (and many more) rules. That is, converting a CFG into Greibach normal form only weakly lexicalises it. The extended domain of locality of a TSG/TAG allows us to avoid this problem, however, and makes tree grammars like this "naturally" lexicalised (Schabes et al. 1988: 579). In fact, to strongly lexicalise an arbitrary CFG, we require a TAG, not simply a TSG (see Kallmeyer 2010: 22–23 for a proof). And although a TSG may be sufficient to lexicalise many linguistically relevant CFGs, it places syntactically undesirable restrictions on the resulting grammar, and so a TAG is preferable here too (Schabes et al. 1988: 579; Schabes 1990: ch. 1). But why should we care whether a grammar is lexicalised or not?

One early advantage touted for lexicalised grammars was based on parsing. In a lexicalised grammar, a given sentence can contain at most as many elementary structures as there are words in the sentence. Since each lexical item is associated with a finite number of elementary structures, this also means that the number of analyses for the sentence is finite, thus guaranteeing that the recognition problem is decidable (Schabes et al. 1988: 581–582). As Kallmeyer (2010: 21; emphasis in original) puts it, "[l]exicalized grammars are *finitely ambiguous*, i.e., no sequence of finite length can be analyzed in an infinite number of ways". However, in practice, the dangers of non-terminating parses are virtually non-existent in sensibly-written natural-language grammars, and so this advantage is not so great as it may seem.[13]

A related claim is that lexicalised grammars assist parsing because "parsing need consider only those trees of the grammar that are associated with the lexical

[13]My thanks to Adam Przepiórkowski and Timm Lichte for discussion of this point.

symbols in the input string" (Eisner & Satta 2000: 79–80), rather than searching the whole grammar, and so the specific words used in a sentence "help to restrict the search space during parsing" (Kallmeyer 2010: 20). Once again, however, this argument carries less practical weight than it might seem, since parsing times for TAG grammars are actually rather slow: the best parsing algorithms for TAGs have a time complexity of $\mathcal{O}(n^6)$, as opposed to $\mathcal{O}(n^3)$ in the case of CFGs, for example (Kallmeyer 2010: ch. 5).[14]

There are, however, more theoretical reasons to be interested in lexicalised grammars. Firstly, it is by virtue of lexicalisation that the derivation tree of a sentence corresponds to its dependency structure (Kuhlmann 2010: 4ff.), as discussed in Section 3.4. Because each elementary object in a lexicalised grammar corresponds to a lexical item, by tracking the combination of those objects we are in fact tracking the combination of lexical items. Especially given the recent interest in dependency grammars prompted by the Universal Dependencies project (Nivre et al. 2016), it is clearly advantageous if our formalism has a transparent connection to dependency structures (see also Haug forthcoming(b) [this volume] on the relationship between LFG and dependency grammars).

Secondly, a lexicalised grammar fits very well with a lexicalist view of syntactic theory. Since the 1970s (at least since the publication of Chomsky 1970), there has been a trend in linguistic theory towards giving lexical analyses of many phenomena which were previously treated as purely syntactic. Indeed, driven by this trend, a plethora of linguistic frameworks have emerged which very deliberately place the lexicon front and centre, treating it as a "richly structured" object, and assuming "an articulated theory of complex lexical structure" (Dalrymple 2001: 3) – this includes LFG, as well as (to a greater or lesser extent) Generalized Phrase Structure Grammar (GPSG: Gazdar et al. 1985), Head-Driven Phrase Structure Grammar (HPSG: Pollard & Sag 1994), Combinatory Categorial Grammar (CCG: Steedman 2000), Minimalism (Chomsky 1995; see also Sells forthcoming [this volume]), and others.[15] Such a focus on the richness of the lexicon is in stark contrast to the historically more prominent view of it as a mere "collection of

[14] Although this is true of TAGs in general, if our only concern is lexicalising an existing CFG-based grammar, then we could likely devise a parser specialised for TAG grammars that lexicalise CFGs which would have a complexity below $\mathcal{O}(n^6)$. My thanks to a reviewer for this observation.

[15] To the extent that Minimalism is truly minimal, i.e. the only syntactic operation is Merge, with constraints being imposed by lexical features, then it is not only lexicalist but also lexicalised (though the use of various "empty" heads arguably still disqualifies it). However, it is also common to assume a number of other operations, such as Agree, which can be sensitive to emergent structural properties not specified in lexical entries, which then undermines the framework's lexicalised status.

the lawless", to use Di Sciullo & Williams's (1987: 4) term, where it is simply a repository of exceptions, "incredibly boring by its very nature", about which "there neither can nor should be a theory" (*ibid.*: 3–4). Given that a lexicalist syntactic theory assumes a richly detailed lexicon, in its most parsimonious form this is *all* it would require, the syntactic component being encoded in the lexical entries themselves. In fact, this is just what lexicalisation provides: in TAG, for example, aside from the basic operations of adjunction and substitution, any other grammatical constraints are described in the elementary trees of lexical items; that is, in the lexicon. In a lexicalised grammar, the lexicon essentially *is* the grammar.[16] This means that every language shares the same computational component, and the only differences between languages are in the lexicon (cf. the Borer-Chomsky Conjecture, mentioned above). This is unlike LFG, for example, where languages differ both in their lexica and in the set of c-structure rules they employ.

6 Factoring out redundancies

Natural language grammars involve a large amount of redundancy: for example, the TAG elementary trees for *loves* and *thinks* shown in Table 1 are identical except for their lexical anchors and for the fact that *loves* takes an NP complement where *thinks* takes an S complement. Similarly, all proper nouns will have elementary trees like *Benjamin*, and all VP adverbs will have elementary trees like *really*, except they may follow rather than precede the VP they modify (i.e. the order of the foot node VP* and the AdvP node may be reversed). There is less redundancy when it comes to trees in an LFG grammar, because elementary trees are broken down into smaller-scale phrase-structure rules, but there is plenty of repetition in functional descriptions, where, for example, all 3sg verbs in English will bear the same annotations describing the person and number of their subjects.

Such redundancy or repetition is unavoidable, but it brings with it two undesirable properties: firstly, from a theoretical perspective, it means that certain generalisations may not be expressed; e.g. there are things that *thinks* and *loves*

[16] Note that it is possible to collapse the lexicon/grammar distinction without also collapsing the word/phrase (or, equivalently, morphology/syntax) distinction: the processes which build word forms, i.e. the leaf nodes of elementary trees in TAG, need not be the same as those which build derived trees in the syntax. Thus, the formal language theory objections to Construction Grammar presented by Asudeh et al. (2013: 4–5) are only objections to the most radical version of the theory, and need not be taken as objections to constructional approaches generally.

have in common, such as requiring a 3sg subject, and so it is not a mere coincidence that there is overlap in their TAG elementary trees or in their LFG functional descriptions. But nowhere in either grammar is this generalisation expressed *qua* generalisation. Secondly, from a grammar engineering perspective, this kind of redundancy makes updating and extending grammars very difficult: if we change how we analyse a particular phenomenon, we have to make sure we change every instance of it in the grammar (e.g. change every transitive elementary tree); and if we introduce a new feature to handle some new phenomenon, we have to make sure it is handled correctly in all the existing structures, by manually adapting them one by one. This is clearly likely to lead to inconsistencies and inaccuracies due to human error.

It is therefore desirable to find a means of factoring out redundancies from a grammar, and expressing the generalisations they capture in a single place. Both LFG and TAG have a means of achieving this. In TAG, it is common practice to make use of a metagrammar, essentially a grammar responsible for generating grammars, where such redundancies can be described just once. Candito (1996, 1999) was one of the first to develop such a metagrammar;[17] her version describes elementary trees along three dimensions: 1) subcategorisation (i.e. how many arguments a verb selects for), including the canonical syntactic functions of the subcategorised arguments; 2) valency alternations/redistribution of syntactic functions; i.e. the actual syntactic function of the arguments; 3) the surface syntactic manifestation of these functions. Each of these dimensions is described by an inheritance hierarchy, and the classes of the metagrammar, corresponding to specific linguistic constructions, such as the English *by*-passive, inherit from one of the terminal classes in the first dimension, one of the terminal classes in the second dimension, and as many of the terminal classes in the third dimension as there are arguments to realise. Constructions can therefore be described by listing the terminal classes they inherit from each of the three dimensions, a label which Kinyon (2000) calls a hypertag (following from the notion of "supertag" introduced by Bangalore 1997 – see also Bangalore & Joshi 2010).

The most recent implementation of the concept of metagrammar is the eXtensible MetaGrammar (XMG) of Crabbé et al. (2013). This does away with Candito's three explicit dimensions, and instead employs a highly expressive de-

[17] Candito's approach was the first to make use of non-destructive inheritance hierarchies, a move which has served as the basis for more modern metagrammar implementations (such as XMG, to be introduced below), but it was not the first to tackle the question of factoring redundancies from TAG grammars. Earlier approaches (Becker 1994 and Srinivas et al. 1994), however, make use of (destructive) lexical rules, which has made them less appealing to researchers who prefer a monotonic approach (I thank a reviewer for bringing this to my attention).

scription language that enables linguistic structures to be given a single, complex description, including multiple levels of representation (e.g. syntax and semantics). It is also designed so that it can be extended to cover new phenomena or linguistic formalisms, and so fewer theoretical assumptions are baked into the formalism. XMG makes use of an inheritance hierarchy, but a single hierarchy instead of Candito's three: rather than taking the approach of describing default syntactic function assignments (dimension 1) and then overriding them with specific valency frames (dimension 2), which might vary, e.g. in the case of diathesis alternations, XMG makes heavy use of disjunctions between alternating descriptions, which enables such alternations to be described fully declaratively, and in just one place. For example, we can express the familiar active-passive diathesis of English as in (32), where each term in italics refers to a class in the metagrammar's inheritance hierarchy that gives a partial description of a (sub-)tree (Crabbé et al. 2013: 616).

(32) $$\begin{array}{lll} \textit{TransitiveDiathesis} & \rightarrow & (\textit{Subject} \wedge \textit{ActiveVerbForm} \wedge \textit{Object}) \\ & & \vee\ (\textit{Subject} \wedge \textit{PassiveVerbForm} \wedge \textit{ByObject}) \\ & & \vee\ (\textit{Subject} \wedge \textit{PassiveVerbForm}) \end{array}$$

Each of the disjuncts in (32) combines these descriptions to give a partial description of a full elementary tree schema (an elementary tree minus its lexical anchor). For now I leave aside the details of how these classes actually describe trees; a simplified version of the logical description language employed will be introduced in the next section. The crucial observation here, and the move which sets XMG apart from earlier approaches to metagrammatical analysis, is that the description in (32) does not privilege one elementary tree/realisation of arguments as basic, but simply describes all possible realisations simultaneously.

The terminal classes of the metagrammar are families of trees which are then associated with lemmas, and represent all the different ways of realising that lemma's arguments (e.g. active vs. passive, *wh*-extraction, clefting, etc.). The *TransitiveFamily* associated with a lemma like LOVE might just consist of (32), while the *DitransitiveFamily* of a verb like GIVE might inherit from the *TransitiveFamily* but add an additional object argument:

(33) $$\begin{array}{lll} \textit{TransitiveFamily} & \rightarrow & \textit{TransitiveDiathesis} \\ \textit{DitransitiveFamily} & \rightarrow & \textit{TransitiveDiathesis} \wedge \textit{IndirectObject} \end{array}$$

This modular and structured approach to the metagrammar means that, for instance, if the analysis of a particular phenomenon changes, we just need to modify the relevant class(es): when the grammar is compiled anew, all of the implicated elementary trees will be altered accordingly. The choice of classes can also have theoretical implications, and may shed light on important linguistic generalisations.[18]

Although the metagrammatical approach has been used to generate LFG grammars as well as TAGs (Clément & Kinyon 2003a,b), this is not common practice in LFG work. Rather, since redundancies in an LFG grammar are far more abundant in the functional descriptions associated with lexical entries than in phrase structure, the standard solution employed here is to make use of TEMPLATES, a type of macro which can be used to abbreviate pieces of functional description that are re-used across lexical entries (Dalrymple et al. 2004, Crouch et al. 2011; see also Belyaev forthcoming(a): sec. 5.1 [this volume]). These templates can take arguments, and can also call other templates, creating a hierarchical organisation – though it should be noted that this is an *inclusion* hierarchy rather than an inheritance hierarchy, since template calls can be negated (Asudeh et al. 2013: 18f.). The semantics of template invocation (represented by prefixing the template name with a '@' symbol) is substitution: the template name is replaced by its contents. This means that a grammar without templates is extensionally equivalent to one with them, but in the latter it will be possible to express generalisations that cannot be expressed in the former.

By way of illustration, (34–35) present some templates which capture some of the same information present in the XMG classes shown above. The TRANSITIVEDIATHESIS template takes a predicate name as its argument, and consists of a disjunction of three other templates; it will be called by the lexical entry of any transitive verb which participates in the active/passive alternation in English. Each of the three templates it invokes provides a PRED value for the verb in question, associating it with the correct set of grammatical functions, and also provides mapping equations which link the GFs to argument positions at semantic structure, or express the fact that the argument is not syntactically realised, in the case of the short passive (this approach to mapping is described in Asudeh & Giorgolo 2012 and Findlay 2016; see also Findlay & Kibort forthcoming: sec. 3.6 [this volume]).

(34) TRANSITIVEDIATHESIS(P) $\equiv$
@ACTIVETRANSITIVE(P) $\vee$ @BYPASSIVE(P) $\vee$ @SHORTPASSIVE(P)

[18] Although metagrammars of this sort can certainly be useful theoretical tools, this is not to say that they are intended as models of how the human language faculty functions. As a reviewer points out, it is perhaps implausible that, in the process of language acqusition, the language learner has to recompile their entire grammar every time they make a change or add a new observation. In this regard, LFG's templates (to be introduced below), which are nothing more than abbreviations, might seem more promising as a model of the learner's competence.

(35) a. $\textsc{ActiveTransitive}(P) \equiv$ $(\uparrow \textsc{pred}) = \text{`}P\langle\textsc{subj}, \textsc{obj}\rangle\text{'}$
$(\uparrow_\sigma \textsc{arg1}) = (\uparrow \textsc{subj})_\sigma$
$(\uparrow_\sigma \textsc{arg2}) = (\uparrow \textsc{obj})_\sigma$

b. $\textsc{ByPassive}(P) \equiv$ $(\uparrow \textsc{pred}) = \text{`}P\langle\textsc{subj}, \textsc{obl}_{\textsc{by}}\rangle\text{'}$
$(\uparrow_\sigma \textsc{arg1}) = (\uparrow \textsc{obl}_{\textsc{by}})_\sigma$
$(\uparrow_\sigma \textsc{arg2}) = (\uparrow \textsc{subj})_\sigma$

c. $\textsc{ShortPassive}(P) \equiv$ $(\uparrow \textsc{pred}) = \text{`}P\langle\textsc{subj}\rangle\text{'}$
$(\uparrow_\sigma \textsc{arg1})_{\sigma^{-1}} = \varnothing$
$(\uparrow_\sigma \textsc{arg2}) = (\uparrow \textsc{subj})_\sigma$

One noteworthy difference between the use of a metagrammar and the use of templates is that the latter but not the former are part of a grammar itself. A metagrammar, as the name suggests, sits outside the grammar proper: it outputs grammars, where the elementary objects do not (necessarily) contain information about which metagrammar classes they instantiate. Templates, on the other hand, are part of the description language of the grammar, although of course they are merely names for pieces of functional description, and so have no special formal status themselves.

7 Combining LFG and TAG

Now that we have seen some of the key concepts of TAG, along with their motivations and apparent benefits, we might wonder whether LFG could also benefit from some of these boons if we were to combine the two approaches – most naturally, by using a TAG instead of a CFG to describe LFG's c-structure. Joshi (2005: 496) described this idea as being "of great interest", and it was previously explored by Kameyama (1986) and Burheim (1996) – but unfortunately only in unpublished work, which has proved impossible to track down. More recently, the idea has been revived by Findlay (2017a,b, 2019). In this section, I outline two different approaches to achieving the goal of combining LFG and TAG, and discuss some of the consequences of adopting such a merger.[19]

7.1 Two approaches

The most straightforward way of combining TAG and LFG is simply to take a TAG grammar and add appropriate LFG annotations to the elementary trees. Of

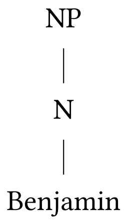
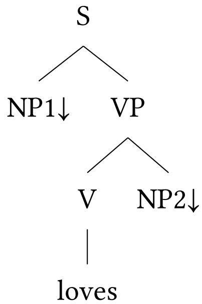
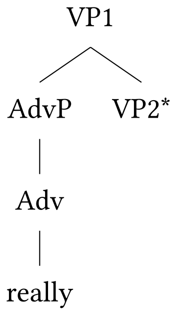
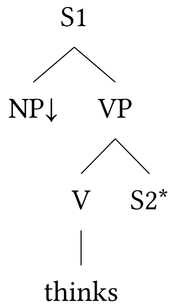
[19]One concern about replacing the CFG component of LFG with a more powerful TAG might be that it makes the formalism as a whole more computationally complex. However, since TAGs are strictly less powerful than LFGs (see Section 4), such a concern is ultimately baseless.

course, once we have access to the whole tree, we gain a greater degree of flexibility in how we express functional annotations. Most notably, we can refer to any node in the tree directly, rather than being limited to the current node or its mother – a consequence of TAG's extended domain of locality. For example, instead of relying on a sequence of $\uparrow = \downarrow$ annotations to pass information from a lexical item to the top of its extended projection, we can refer to the top directly. For the sake of simplicity, let us use node labels as shorthand for the nodes themselves.[20] Then the ($\uparrow$ PRED) = 'love' annotation on the verb *loves*, for example, could be rewritten as (S_ϕ PRED) = 'love', using S_ϕ to refer to the f-structure of the clause directly, rather than indirectly via V_ϕ (the instantiation of $\uparrow$), which is equated with both VP_ϕ and S_ϕ. Indeed, since we can use absolute rather than relative labels for the nodes in the tree, there is no need to mark annotations actually on the tree at all; instead, we can treat lexical entries as pairs consisting of the tree on the one hand and the annotations on the other, which refer to nodes in the tree. This arguably simplifies the process of determining an f-structure from an annotated c-structure, since many identities which would normally have to be computed are instead already given in the descriptions. Table 2 shows the elementary trees from Table 1 augmented in this fashion. The trees then combine as usual for a TAG, using the operations of substitution and adjunction, albeit understood in a particular fashion. Substitution involves identifying two nodes, so that, e.g. if the tree for *Benjamin* were substituted into the subject position of the tree for *loves*, NP and NP1 would be identified (and therefore so would their f-structures, requiring the nodes to bear compatible annotations – and thereby accounting for the agreement facts, for example). Adjunction involves three steps: first we excise a sub-tree rooted at the adjunction site; next, we *replace* it with the adjoining auxiliary tree; finally, we unify the foot node of the auxiliary tree with the root node of the excised sub-tree it replaced.[21] This way, we identify the

[20] Of course, in reality nodes and their labels are distinct: several nodes can bear the same label, for example (e.g. there can be more than one NP in a tree). When this happens, I follow the TAG convention of suffixing node labels with numbers (e.g. NP1 and NP2), but it should be borne in mind that this is just a representational choice, and that in reality such nodes have identical labels.

[21] Note that it is particularly important in this setting that adjunction is only defined where the adjoining tree's root and foot nodes are of the same category. In some TAG settings this would not need to be stated explicitly, depending on how adjunction is defined, but here the root of the auxiliary does not unify with anything, and so there is nothing which formally requires the root and foot nodes of such a tree to have the same category (I thank a reviewer for this observation). Allowing trees with mismatched root and foot nodes to participate in adjunction would have undesirable consequences: for example, we do not want the tree for *loves* in Table 2 to act as an NP modifier (e.g. **the Benjamin loves boy*).

Table 2: Some elementary trees with associated LFG annotations

Initial trees	
	$\mathrm{NP}_\phi = \mathrm{N}_\phi$ $(\mathrm{NP}_\phi\ \textsc{pred}) = \text{‘Benjamin’}$ $(\mathrm{NP}_\phi\ \textsc{num}) = \textsc{sg}$ $(\mathrm{NP}_\phi\ \textsc{pers}) = 3$
	$\mathrm{S}_\phi = \mathrm{VP}_\phi = \mathrm{V}_\phi$ $(\mathrm{S}_\phi\ \textsc{pred}) = \text{‘love’}$ $(\mathrm{S}_\phi\ \textsc{tense}) = \textsc{pres}$ $(\mathrm{S}_\phi\ \textsc{subj}) = \mathrm{NP1}_\phi$ $(\mathrm{S}_\phi\ \textsc{obj}) = \mathrm{NP2}_\phi$ $(\mathrm{NP1}_\phi\ \textsc{num}) = \textsc{sg}$ $(\mathrm{NP1}_\phi\ \textsc{pers}) = 3$
Auxiliary trees	
	$\mathrm{VP1}_\phi = \mathrm{VP2}_\phi$ $\mathrm{AdvP}_\phi = \mathrm{Adv}_\phi$ $(\mathrm{AdvP}_\phi\ \textsc{pred}) = \text{‘really’}$ $\mathrm{AdvP}_\phi \in (\mathrm{VP1}_\phi\ \textsc{adj})$
	$\mathrm{S1}_\phi = \mathrm{VP}_\phi = \mathrm{V}_\phi$ $(\mathrm{S1}_\phi\ \textsc{pred}) = \text{‘think’}$ $(\mathrm{S1}_\phi\ \textsc{tense}) = \textsc{pres}$ $(\mathrm{S1}_\phi\ \textsc{subj}) = \mathrm{NP}_\phi$ $(\mathrm{S1}_\phi\ \textsc{comp}) = \mathrm{S2}_\phi$ $(\mathrm{NP}_\phi\ \textsc{num}) = \textsc{sg}$ $(\mathrm{NP}_\phi\ \textsc{pers}) = 3$

target of adjunction with the foot of the auxiliary tree, and correctly distribute the annotations between the two “parts” of the expanded node without the need for top and bottom feature structures.[22, 23]

This first approach is much more in the spirit of TAG than of LFG, since the c-structure component is DERIVATIONAL, making use of the combining operations of substitution and adjunction. Let us therefore call it LFG-TAG. But as Kaplan (1995: 11) points out, this PROCEDURAL, or CONSTRUCTIVE, approach to grammatical analysis is in contrast to the DESCRIPTIVE (a.k.a. DECLARATIVE or MODEL-BASED) approach which is the "hallmark of LFG" (*ibid.*). Findlay (2019: ch. 5) therefore explores another way of combining the two frameworks which is more in keeping with the LFG spirit. In brief, we associate lexical entries with *descriptions* of trees, rather than with the trees directly, as is standard practice in metagrammars, for instance.[24] In the simplest cases there is a one-to-one corre-

[22] A reviewer asks how obligatory adjunction can be implemented in this setting, since in FTAG it exploits the possibility of mismatching top and bottom features (see Section 3.3). Ultimately, the answer is that the greater expressive power of the LFG projection architecture means that the effects of obligatory adjunction constraints will be captured in different ways in different situations. There is no worry about expressivity in general, since LFG is already at least context sensitive. For specific linguistic applications, constraining equations will frequently be relevant: for example, returning to the example of *to leave* from (18), to implement the SA constraint we might specify that *tried* requires its COMP to contain the feature [FINITE −], whereas *imagined* requires it to contain [FINITE +]; if *to leave* specifies that its f-structure contains [FINITE −], then it will be compatible with the former but incompatible with the latter. If we wish to avoid *to leave* appearing on its own (i.e. we rule out fragments), we might implement a general ban on root f-structures containing [FINITE −], or we might rely on the resource sensitivity of Glue Semantics, since an infinitive alone will not permit a linear logic proof terminating in the goal type of propositions.

[23] Findlay (2017a: 222, fn. 12) claims that we are forced to adopt the second proposal to be discussed below, using descriptions of trees, because adjunction means that the ↑ and ↓ chains in annotations will be disrupted. This would be true if we were forced to refer to f-structures only indirectly, via mother-daughter links, but fails to appreciate the additional freedom afforded by being able to refer to nodes absolutely, as discussed above. There is, however, a small wrinkle when it comes to verbal trees for extraction constructions (e.g. *wh*-questions): if nothing is adjoined to them, we want to unify the f-structures of the root S and the S node it immediately dominates; but if a sentential embedding verb is adjoined there, we cannot identify the two f-structures, or else we will end up with a cyclic f-structure which is its own COMP. All this shows us though is that we have to take care when writing the functional annotations. Here, for example, we can solve the problem by actually reintroducing an element of relativity: we identify the root node's f-structure with the f-structure of its S daughter (e.g. by defining a predicate CATDAUGHTER(n, C) which identifies the unique daughter of node n which bears label C, and is undefined if there is none or more than one), regardless of which node that actually ends up being. I omit the formal details of how this can be achieved, since ultimately we will settle on the second approach to integrating TAG and LFG described below, but it is important to note that this first approach is not unworkable.

[24] The use of tree descriptions has been discussed extensively in the context of TAG – see, for instance, Vijay-Shanker (1992), Rogers & Vijay-Shanker (1994), Rambow et al. (1995, 2001), Kallmeyer (2001).

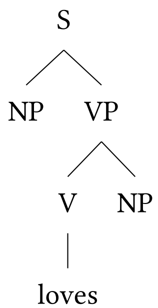
spondence between a description and the (minimal) tree it describes, and so we could straightforwardly translate LFG-TAG into a more LFG-like format. However, descriptions can also make use of negation, disjunction, or other operations that go beyond simple conjunction of propositions, and in this case the relation between descriptions and trees is no longer isomorphic (Kaplan 1995: 14).

In order to add descriptions of trees to LFG lexical entries, we need a suitable language to write the descriptions in. There are a variety of different possibilities, but here we will assume a fairly simple language based on that used in XMG (Crabbé et al. 2013: 599), which will consist of the following:[25]

(36)
1. a set N of node variables
2. a set P of unary labelling predicates, including all terminal and non-terminal labels
3. the following binary predicates:
   - $\rightarrow$, immediate dominance (the *mother-of* relation)
   - $\rightarrow^*$, dominance (the transitive, reflexive closure of $\rightarrow$)
   - $\prec$, linear precedence[26]

The tree in (37) can then be described by the set of constraints in (38):[27]

(37)



[25] We will also assume that sufficient axioms are in place to ensure the usual well-formedness conditions on trees, e.g. that they are singularly rooted, that branches cannot cross, etc. Rogers (1998: 15–16) gives one such set of axioms.

[26] Here this is to be understood as the transitive closure of immediate linear precedence, i.e. what Crabbé et al. (2013: 599) represent as $\prec^+$. In other words, a node linearly precedes everything to its right, but does not linearly precede itself.

[27] In descriptions, we will assume that all node variables are ultimately existentially bound.

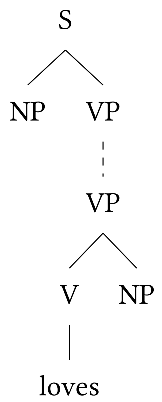
(38)

S(n_1)	$n_1 \rightarrow n_2$	$n_2 \prec n_3$
NP(n_2)	$n_1 \rightarrow n_3$	$n_4 \prec n_5$
VP(n_3)	$n_3 \rightarrow n_4$	
V(n_4)	$n_3 \rightarrow n_5$	
NP(n_5)	$n_4 \rightarrow n_6$	
loves(n_6)		

However, as it stands, the constraints in (38) are too rigid. Specifically, they will not allow adjunction at the VP node, since then at least one statement in the description will no longer be true: if we identify the target n_3 with the root of the adjoining tree, then $n_3 \rightarrow n_4$ will no longer hold (the foot node of the auxiliary tree will dominate n_4 instead), and if we identify it with the foot node of the adjoining tree, then $n_1 \rightarrow n_3$ will not be true instead. The basic problem is that "[t]he composition operation of adjoining creates a new structure that does not maintain all of the properties that held in the original (fully specified) structures of which it is composed" (Vijay-Shanker 1992: 486). What this means is that we cannot operate with fully specified descriptions, but must make use of partial descriptions instead.

For each node where adjunction can apply, we instead describe a pair of QUASI-NODES which stand in the dominance relation (Vijay-Shanker 1992: 486ff.). That is, instead of (38), we have (40), which is represented schematically in (39) (where a dashed line represents dominance rather than immediate dominance):

(39)



(40)

S(n_1)	$n_1 \rightarrow n_2$	$n_2 \prec n_3$
NP(n_2)	$n_1 \rightarrow n_3$	$n_5 \prec n_6$
VP(n_3)	$n_3 \rightarrow^* n_4$	
VP(n_4)	$n_4 \rightarrow n_5$	
V(n_5)	$n_4 \rightarrow n_6$	
NP(n_6)	$n_5 \rightarrow n_7$	
loves(n_7)		

As elsewhere in LFG, we take the solution to a set of constraints to be the *minimal* structure (or structures) which satisfies all the constraints. Since the dominance relation is reflexive, the minimal tree which satisfies (40) remains (37), i.e. one where we equate n_3 and n_4. But, crucially, if something is adjoined here, the nodes can come apart, with the result that n_3 is identified with the root of the auxiliary tree and n_4 with its foot node.

Now that we have a description of this tree, we can combine it with functional descriptions to form a full LFG lexical entry:[28]

(41)

S(n_1)	$n_1 \rightarrow n_2$	$n_2 \prec n_3$	$n_{1\phi} = n_{3\phi}$
NP(n_2)	$n_1 \rightarrow n_3$	$n_5 \prec n_6$	$n_{4\phi} = n_{5\phi}$
VP(n_3)	$n_3 \rightarrow^* n_4$		$(n_{5\phi}\ \textsc{pred}) = \text{‘love’}$
VP(n_4)	$n_4 \rightarrow n_5$		$(n_{5\phi}\ \textsc{tense}) = \textsc{pres}$
V(n_5)	$n_4 \rightarrow n_6$		$(n_{1\phi}\ \textsc{subj}) = n_{2\phi}$
NP(n_6)	$n_5 \rightarrow n_7$		$(n_{4\phi}\ \textsc{obj}) = n_{6\phi}$
loves(n_7)			$(n_{2\phi}\ \textsc{num}) = \textsc{sg}$
			$(n_{2\phi}\ \textsc{pers}) = 3$

To parse a sentence, we just collect up all of the constraints associated with each lexical item and find the minimal structures – both c-structure and f-structure – which satisfy them.

[28]Here I have kept to a more conservative annotation scheme than above, whereby e.g. lexical contributions are associated with the f-structure of n_5, i.e. the V node, rather than with that of the root S. This is because adjunction may in principle alter the structure of the tree so that it is no longer the case that the f-structure of the S node is the same as the f-structure of the V node. In fact, with verbal trees like this, that will not be the case, because the only auxiliary trees which target VPs in a TAG grammar will be auxiliary verbs or adverbial modifiers, neither of which will break the link between V and S in terms of f-structure-identity. But it will be relevant for trees containing extraction sites, for example, which can be targetted by sentential embedding verbs, and where the root's f-structure will thereby be separated from the head verb's.

Of course, (41) is not particularly readable, so we might prefer to collect some parts of the description in various templates. For example, the tree for any transitive verb will share most of the description in (41), so we can factor out this part of the description, parametrising the only variable, namely the lexical anchor:

(42) TransitiveTree($s, np_1, vp_1, vp_2, v, np_2, a, anchor$) $\equiv$

S(s)	$s \rightarrow np_1$	$np_1 \prec vp_1$	$s_\phi = vp_{1\phi}$
NP(np_1)	$s \rightarrow vp_1$	$v \prec np_2$	$vp_{2\phi} = v_\phi$
VP(vp_1)	$vp_1 \rightarrow^* vp_2$		$(s_\phi \text{ SUBJ}) = np_{1\phi}$
VP(vp_2)	$vp_2 \rightarrow v$		$(vp_{2\phi} \text{ OBJ}) = np_{2\phi}$
V(v)	$vp_2 \rightarrow np_2$		
NP(np_2)	$v \rightarrow a$		
anchor(a)			

In fact, we have to "expose" all nodes as parameters of the template, so that they can be referred to by other constraints in the same lexical entry, thereby taking advantage of the extended domain of locality afforded by having the description of the whole tree in one place. However, since all of the parameters in (42) except the lexical anchor will simply be node variables, I propose a shorthand: when calling the template, all but the last parameter will be omitted (though, to repeat, when defining it all the parameters must be specified); if we wish to refer to any of the other parameters, we can do so by using the template name and suffixing it with the appropriate parameter.[29] For example, TransitiveTree.*s* refers to the first parameter, a node variable which corresponds to the root node *s* in (42). With these conventions in place, we can write a more readable lexical entry for *loves* as follows (using a local name, %up, to refer to the verb's f-structure – see Belyaev forthcoming(a): sec. 3.2.5 [this volume] for the details on local names):[30]

[29]This is based on the conventions of XMG for exported variables (Crabbé et al. 2013: 602–604).

[30]Here I have reverted to describing the agreement constraints on the subject via the clause's f-structure rather than via the NP's, to make this lexical entry closer to the LFG standard. But of course the option is still open to us to describe it via the tree directly, by associating TransitiveTree.$np_{1\phi}$ with a name, e.g. %subj-np, and then declaring that (%subj-np num) = sg. Although these options are extensionally equivalent, there can be theoretical/descriptive reasons to prefer one over the other. Cross-linguistically, for example, we might want to treat subject agreement as the same kind of phenomenon both in languages where phrase-structure position is a clear guide to grammatical function (like English) and in languages where it is not (like Warlpiri); so it would make sense to retain the standard LFG approach of describing agreement via f-structure. But in other cases it might make more sense to refer to a particular phrase-structure position, and the integration of an extended tree description into the lexical entry means we now have that choice.

(43) @TransitiveTree(loves)
%up = TransitiveTree.v_ϕ
(%up pred) = 'love'
(%up tense) = pres
(%up subj num) = sg
(%up subj pers) = 3

One theoretical advantage of this approach is that we can build up trees from smaller parts by making use of nested template calls. This allows us to capture connections between phrasal configurations in a way which CFG rules do not. For example, there is no relationship between the two rules in (44), even though the latter is obviously partially described by the former:[31]

(44) a. VP $\longrightarrow$ V ($\uparrow = \downarrow$) NP ($(\uparrow \text{OBJ}) = \downarrow$)

b. VP $\longrightarrow$ V ($\uparrow = \downarrow$) NP ($(\uparrow \text{OBJ}) = \downarrow$) NP ($(\uparrow \text{OBJ}_\theta) = \downarrow$)

On the other hand, if we have a template DitransitiveTree which calls the TransitiveTree template (as well as another template which adds a secondary object), then this containment relationship is made explicit:

(45) DitransitiveTree(*anchor*) ≡ @TransitiveTree(*anchor*)
@SecondaryObject

Of course the TransitiveTree template can also be decomposed into a call of an IntransitiveTree template plus a PrimaryObject one, and so on. By continuing along these lines, we can capture all the various generalities across trees in a template inclusion hierarchy, recreating the class hierarchies of a TAG metagrammar inside an LFG grammar itself.

[31]Of course, we can use the convention of surrounding optional nodes in parentheses, and then we can express the relationship between the two rules within a single phrase-structure rule as follows:

(i) VP $\longrightarrow$ V ($\uparrow = \downarrow$) NP ($(\uparrow \text{OBJ}) = \downarrow$) (NP ($(\uparrow \text{OBJ}_\theta) = \downarrow$))

However, once we move beyond simple examples like this, such an approach becomes unwieldy, with multiply nested parentheses and very complex disjunctions. Unlike the templatic approach, which provides a readable front-end to the formal complexity, and allows us to represent the relationship(s) between sub-trees in an inclusion hierarchy, this approach forces us to create fewer but more complex rules, which does nothing to aid human-readability.

7.2 Implications

Having now seen how LFG and TAG can be combined, let us consider the consequences of such a merger. There are several potential gains which such a move could bring, along with several unanswered questions which require further research.

Firstly, the second approach described above offers a pleasing harmonisation of LFG lexical entries. Standard LFG lexical entries contain descriptions of all levels of the projection architecture, but since such lexical entries are really just context-free phrase-structure rules, the description of c-structure is limited to information about the word itself and its mother. In contrast, descriptions of all other levels of structure can refer to arbitrarily distant elements (via functional uncertainty). The inclusion of tree descriptions removes this irregularity from the grammar, since now non-local elements of c-structure can also be included.

Secondly, we now have the opportunity to lexicalise an LFG grammar (indeed, Findlay 2019: ch. 5 calls the description-based approach described above "Lexicalised LFG"). As outlined above, especially in Section 5, the extended domain of locality of a TAG means that all dependencies, including long-distance ones, can be encoded locally in a lexical entry. Lexicalisation seems a natural goal for a lexicalist theory like LFG, and it is perhaps lamentable that it was not possible before.

Thirdly, we can now straightforwardly account for idioms (Findlay 2019: ch. 6). These are problematic for the current leading account of constructions in LFG (Asudeh et al. 2013), since they do not simply add additional constructional meaning to existing lexical meaning, but rather *replace* the lexical meaning with another, different meaning (that is, *shooting the breeze* involves neither shooting nor a uniquely contextually salient breeze). This forces lexicalist theories like LFG to adopt an approach which treats idioms as conspiracies of independent lexical items that select for one another (see Findlay 2022: sec. 4.3). Such approaches face a host of problems, not least of which is that they singularly fail to capture our intuitions about idioms – *viz.* that they are "things" (as Williams 2007 puts it), and not mere epiphenomena of the grammar (see Findlay 2019: 58ff. for discussion of various other problems). But now that we can have lexical entries containing multiple, separable word forms, something which is not possible in vanilla LFG, there is no obstacle to encoding multiword expressions in a single place, thus enabling a much more satisfying analysis. Findlay (2019: ch. 3) provides detailed discussion of the need for this kind of constructional approach to idioms, as well as arguments against other types of analysis.

Fourthly, as well as idioms, we have a straightforward account of constructional phenomena more broadly. Similar arguments can be made here about the need for constructions to have some ontological status in the theory – to be "things".[32] Admittedly, Asudeh et al. (2013) demonstrate that we do not need to admit constructions as first-class entities in our theory in order to explain *some* kinds of constructional effects, but they only consider constructions which can be described by a single lexical entry or a single context-free phrase-structure rule, and so the constructions in question can be described in a single place. Other constructions require reference to wider spans of phrase structure, or require the presence of multiple specific words, potentially in quite distant parts of the phrase, and here the approach will once again have to rely on multiple interacting lexical entries and phrase-structure rules which conspire to give the correct constructional effects. Even if this gives the right results, one might, again, object that it does so for the wrong reasons, since it fails to account for the unitary nature of constructions as grammatical objects. By contrast, in the description-based approach to merging TAG and LFG, although constructions are still not added as new objects in the ontology of the theory, they nevertheless have a kind of first-class status, since they can either be entire (complex) lexical entries or be a part of a lexical entry in the form of a tree template which can be called by all the different words which can fill the empty slots in the construction. See Findlay (2022) for a broader discussion of the connection between LFG and Construction Grammar, and for arguments that vanilla LFG is inadequate to give a satisfactory analysis of certain multiword (substantive) constructions.

Alongside these advantages of combining LFG and TAG, there remain some unexplored implications which are ripe for future work. Firstly, one of the parade examples of LFG's utility is in describing languages with highly flexible word orders, such as Warlpiri (see e.g. Bresnan et al. 2016: ch. 1). With TAG's focus on configurational properties, we need to ensure that incorporating a TAG into LFG does not undo its ability to describe these non-configurational languages. Given the flatter tree structures generally assumed for such languages (Simpson 1991, Austin & Bresnan 1996), a first pass solution in the present framework would be to simply make use of looser tree descriptions, which, for example, lack linear

[32]There is suggestive psycho- and neurolinguistic evidence that the way we process language makes heavy use of prefabricated chunks ('prefabs') (Pawley & Syder 1983, Wray 2002) and of constructions more generally (Bencini & Goldberg 2000, Kaschak & Glenberg 2000, Goldwater & Markman 2009, Pulvermüller 2010, Allen et al. 2012, Johnson & Goldberg 2012). Obviously grammatical theory need not have anything to say about how language is processed in the mind, but it might still be seen as an advantage if it at least makes available the kinds of objects the mind seems to work with – e.g. constructions.

precedence relations between a verb and its arguments, so that the the entry for a verb does not describe a unique minimal tree, but rather several minimal trees which represent the different orderings of arguments. Of course, these different orderings are not just random, and actually correspond to different information structures, so simply allowing free choice between them is inadequate. Instead, we should once again make use of disjunction, this time between the descriptions corresponding to the different orderings of verb and arguments, where each of the different word orders is also accompanied by the correct information-structural annotations.

Such languages also often permit discontinuous constituents, and these will require their own solution. For example, some adjuncts might be represented not as auxiliary trees that induce a more articulated structure, but rather as simpler trees whose root merely unifies with another node, such as the clausal root S, adding the adjunct as a sister to the existing daughters. Obviously this sketch needs to be developed into a fully fleshed-out proposal before we can be confident that no analytical clout has been lost.

Another open question arises from the fact that using a TAG as the basis of the c-structure component means that we can employ adjunction to account for long-distance dependencies. This then removes a foundational motivation for functional uncertainty (Kaplan & Zaenen 1989), one of the major sources of formal complexity in LFG. Unfortunately, this does not mean we can simply remove functional uncertainty from the formalism, since it has been employed by researchers in various other domains beyond filler-gap dependencies – most notably in LFG's binding theory (e.g. Dalrymple 1993, Dalrymple et al. 2018). Determining whether these analyses can be reformulated so that functional uncertainty could be done away with altogether remains a task for future work, perhaps drawing on existing TAG analyses of binding (e.g. Ryant & Scheffler 2006, Champollion 2008, Storoshenko et al. 2008, Storoshenko & Han 2013).

Lastly, including a description of a tree which incorporates the full extended projection of a predicate in its lexical entry means that we can take a rather different view of argument structure. A predicate's arguments and the possibilities for their realisation can be encoded directly in its lexical entry, rather than relying on a separate level of representation like a-structure (on which see Findlay & Kibort forthcoming [this volume]). And alternative argument realisations, e.g. diathesis alternations, can be expressed through disjunctive templates, as discussed above in parallel with XMG, rather than through a separate mechanism of mapping between a-structure and f-structure. Work on developing templatic approaches to argument structure include Asudeh & Giorgolo (2012), Findlay (2016, 2020), Przepiórkowski (2017), but these do not take c-structure into account: with the new

TAG perspective, the phrase-structural effects of argument structure/mapping phenomena can also be directly expressed.

8 Conclusion

Tree-Adjoining Grammar offers a rather different perspective on some grammatical phenomena from that of CFG-based formalisms.[33] For instance, it allows us to describe constraints on filler-gap relationships via the structure of the elementary trees in the grammar rather than via an independent principle like Subjacency. It also provides a natural account of the fact that many "lexical" items in fact incorporate several distinct word forms (e.g. phrasal verbs, compounds, idioms), and of constructional meaning, by virtue of its expanded concept of locality. And, computationally speaking, it possesses just the right degree of context-sensitivity to account for natural languages while remaining parsable in polynomial time. Nonetheless, its representation of dependency structures is imperfect, and its focus on the primacy of phrase structure leaves it somewhat impoverished when compared to the richly expressive parallel projection architecture of LFG, which facilitates a much fuller view of the grammar as a whole. Combining the two approaches might therefore offer a tempting opportunity to acquire the best of both worlds. In Section 7 we saw how this could be achieved, and the possibilities this affords for LFG, both in terms of descriptive power and in terms of potentially further-reaching formal or architectural changes.

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[33]TAG has also played an important role outside of theoretical linguistics – specifically in both computational linguistics (see e.g. Kallmeyer et al. 2008, Kasai et al. 2017, Koller 2017) and psycholinguistics (see e.g. Ferreira 2000, Ferreira et al. 2004).

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