Argument structure and mapping theory

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1 Introduction

The theoretical status of argument structure as a level of representation – its formal characteristics, its position in the architecture of the grammar, what it is intended to explain – has varied perhaps more than that of any other in LFG. Partly, this reflects the state of the art in the field of theoretical linguistics more widely, but it also plays out as a decidedly framework-internal debate about the modular architecture of the grammar. For the sake of clarity, in this chapter we draw a terminological distinction between the phenomenon under discussion and the theoretical construct used to account for it. The former we call "argument structure", and it includes the information a predicate contributes about which of its arguments can be syntactically expressed, the semantic relation(s) they bear to the predicate, and the possibilities for their mapping to syntax. The latter we call "a-structure", and it may or may not be explicitly incorporated into the LFG projection architecture. This situation is analogous to usage elsewhere in LFG: for example, the "constituent structure" of a sentence is an empirical phenomenon, and "c-structure" is the theoretical construct used to model it. Argument structure is clearly something which any theoretical account of language must account for; a-structure is a tool such a theory may or may not make use of in doing so (that is, there need not be a single, dedicated structure which represents argument structure properties).

The second part of our title refers to the theory which seeks to give an account of the linking between the semantic participants of an event and their syntactic realisation. Various names have been employed for such a theory in the LFG literature: LEXICAL MAPPING THEORY (LMT) is perhaps the most widespread, although several scholars have pointed out the problems with seeing the theory as applying purely in the lexicon,[1] and therefore the "Lexical" is often dropped, giving us MAPPING THEORY *tout court* (as in e.g. Kibort and Maling 2015). Other names include FUNCTIONAL MAPPING THEORY (Alsina, 1996b) and LINKING THEORY (Butt, Dalrymple, and Frank, 1997). Here we use "mapping theory" (no capital letters) as a cover term for all such theories. Any mapping theory has to contend with the fact that predicates can often express their semantic participants in a variety of different ways, e.g. via diathesis alternations like active-passive, productive derivational processes like causativisation or applicativisation, and morphosemantic alternations like dative shift. In a lexicalist framework like LFG, such alternations are generally taken to be operations which manipulate argument

[1] Work on complex predicates (e.g. T. Mohanan, 1994; Butt, 1995; Alsina, 1996b) showed that some of the relevant processes involve multiple lexemes, and so argument structures must be attributes of clauses, not (just) individual words: see Section 3.3. This undercuts the lexicalist view of such alternations, since they cannot, as a rule, apply exclusively in the lexicon.

structures, thus connecting the two parts of our title. Indeed, often (and especially in LFG), a-structure is assumed to exist only in order to facilitate mapping, to the extent that it is frequently represented as nothing more than a list of arguments, ordered according to one or another theory of prominence (e.g. Bresnan and Kanerva, 1989; Grimshaw, 1990, p. 28; T. Mohanan, 1994).

A proper and thoroughgoing overview of research on argument structure and mapping theory could fill several volumes.This is because argument structure stands at the interface between the lexicon and the grammar, and so, naturally, it is invoked in the analysis of a large number of phenomena. What is more, since argument structure represents a fundamental distinction in grammatical theory, i.e. between what is stored and what is computed in language, questions about its nature are of fundamental importance, and are foundational issues for a number of debates – for example, the opposition between Construction Grammar and Mainstream Generative Grammar (to use Culicover and Jackendoff's 2005 term) is fundamentally about where, or even if, one draws the dividing line between lexicon and grammar.

There are already many overviews and critical reviews of work on argument structure and mapping theory in general (Grimshaw, 1990; Comrie, 1993; B. Levin and Rappaport Hovav, 2005; Ramchand, 2014; Williams, 2015), and so here we focus on providing a survey of the key works within LFG. Even with this focus, though, choices have to be made. We have selected works which have proved influential, either because their approaches were taken up directly by subsequent researchers, or because their empirical, theoretical, or formal observations/innovations were. We have tried to do this in as fair a manner as possible, but of course recognise that not everyone will agree with our choices.

In keeping with our source material, we will focus our attention in this chapter on the representation and realisation of verbal arguments, and not those of nouns (Grimshaw, 1990) or other predicates (Stowell, 1983; Stowell, 1991). The verbal domain is certainly the most complex, with a variety of alternations which are not found elsewhere, but of course other kinds of argument structures offer their own unique challenges. See the Further Reading section for more resources on nominal argument structures in particular.

The structure of the chapter is as follows. Section 2 contains a brief discussion about the purpose of mapping theory and how work in LFG accords with this. Section 3, the bulk of the chapter, gives a history of some key argument structure and mapping theory proposals in LFG. Finally, Section 4 offers conclusions, and is followed by a Further Reading section which guides the reader to additional research, especially on topics not discussed in the body of the chapter.

2 What is mapping theory for?

There are regularities in the ways that semantic participants of predicates are realised syntactically. For example, in a nominative-accusative language like English, when a verb describes an event that has a volitional Agent and an Undergoer affected by the event, the Agent will be realised as the grammatical subject and the Undergoer as the object (in the active voice):

(1) a. The teacher opened the cupboard.
(NOT: #The cupboard opened the teacher.[2])

[2]Of course, this alternative sentence is ill-formed only as a way of expressing the intended meaning that

b. Your dog is chasing my rabbit!
(NOT: #My rabbit is chasing your dog!)

c. The engineers will build the bridge there.
(NOT: #The bridge will build the engineers there.)

Similarly, if the sentence expresses an Instrument used to perform the action described, along with the Undergoer, then the Instrument is the subject and the Undergoer the object:

(2) a. The key opened the cupboard.
(NOT: #The cupboard opened the key.)

But if the Agent is also included, then *it* is the subject:

(3) The teacher opened the cupboard with the key.

This generalisation goes back to Fillmore (1968, p. 33), who expresses it as follows:

(4) If there is an A [= Agent], it becomes the subject; otherwise, if there is an I [= Instrument], it becomes the subject; otherwise, the subject is the O [= objective, i.e. Undergoer].

That this is a productive generalisation can be seen from the fact that invented words will also follow the same pattern. For instance, Alsina (1996b, pp. 5–6) imagines a verb *obliquate*, meaning 'build or place in an oblique position or direction', and notes that it is clear that, if such a verb existed, we would say things like (5a), but not like (5b):

(5) a. Jim obliquated the door of the closet.

b. # The door of the closet obliquated Jim.

In other words, the semantic relationship which an argument bears to its verb is also implicated in determining its syntactic relationship. Mapping theory is interested in discovering the nature of this connection, and in finding generalisations over the links between semantic and syntactic relationships.

Mapping theory also concerns itself with the fact that a single predicate may permit multiple ways of expressing its arguments (including not expressing some of them at all) – so-called ARGUMENT ALTERNATIONS. Perhaps the most famous is the active-passive alternation, whereby a transitive verb alternates with an intransitive version in which the subject argument of the transitive form is either unexpressed or expressed as a non-core, oblique grammatical function instead:

(6) a. *Active:*
The dog licked the rabbit.

b. *Passive:*
The rabbit was licked (by the dog).

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the teacher caused the cupboard to open; it is perfectly acceptable as a means of expressing the, less plausible, meaning where the cupboard caused the teacher to open. For this reason, we mark it as semantically anomalous (#) rather than ungrammatical (*).

Such alternations can be highly productive, and a mapping theory must give a general account of them.

Some questions of mapping depend not on the semantic relationship between an argument and its verb, but rather on lexical semantic properties of the verb itself. For example, Fillmore (1970) observes that the contrast in (7–8) between *hit* and *break* is not a lexical idiosyncrasy of these two verbs, but actually applies to two large classes of semantically-related verbs, as shown in (9–10):

(7) a. The teacher broke the ruler.
b. The ruler broke.

(8) a. The teacher hit the ruler.
b. * The ruler hit

(9) a. The teacher {bent / folded / shattered / cracked / . . . } the ruler.
b. The ruler {bent / folded / shattered / cracked / . . . }.

(10) a. The teacher {slapped / struck / bumped / stroked / . . . } the ruler.
b. * The ruler {slapped / struck / bumped / stroked / . . . }.

Once again, we can see that this is a productive generalisation if we examine our intuitions about invented forms. For example, let us imagine a verb *jellate*, meaning 'to turn to jelly': it is clear that this verb could appear in the same constructions as *break*.

(11) a. The wizard jellated the box.
b. The box jellated.

But if we invent a word like *coude*, meaning 'to touch with one's elbow', it is just as clear that it will pattern with *hit*:

(12) a. I couded the wall.
b. *The wall couded.

We do not want to simply stipulate the possibilities for each new verb, since then we fail to capture the regularity and productivity of our intuitions. A mapping theory ought to give an account of these patterns.

Taking all of this into account, the least we require of a mapping theory is that it can describe regularities in mapping, and thereby avoid redundant repetition in grammatical descriptions.[3] This level of analysis is analogous to Chomsky's (1964) DESCRIPTIVE ADEQUACY: we correctly describe the facts, and can make predictions about future data points – e.g. we should be able to account for the nonce words discussed above. Of course, in order to do this, we need to understand *by virtue of what* the descriptive generalisations hold. And it seems clear that semantic properties of the verb, including both the semantic relations between the verb and its arguments and intrinsic properties of the eventuality it describes, must constitute some part of these antecedent facts. Indeed, there have been very detailed studies on the connections between lexical semantics and argument structure outside of LFG (e.g. Jackendoff, 1975; B. Levin and Rappaport Hovav, 2005; Ramchand, 2008; Croft, 2012).

[3]Notice that this avoidance of redundant repetition in grammar writing is also the purpose of TEMPLATES (Crouch et al., 2008; Dalrymple, Kaplan, and King, 2004; [72ff.]chapters/CoreConcepts); this connection becomes significant in some recent work on mapping theory, where templates are used to capture mapping generalisations – see Section 3.6.

However, LFG lacks an established theory of lexical semantics, and so work within the framework has largely focussed on the semantic relations between arguments and the verb, rather than on properties of the eventuality described by it (one important exception is Butt 1995, discussed in Section 3.3 – see also the collection of papers in Butt and King 2006 [1983]). This means most LFG work on mapping has relied on the notion of THEMATIC ROLE in one form or another, where thematic roles are supposed to be macro-level generalisations over more predicate-specific semantic relations. These roles can, for example, be linked intrinsically to a set of possible GRAMMATICAL FUNCTIONS (GFs) which can realise them syntactically, or they can be ranked in a hierarchy which gives rise to relative preference constraints on which GFs can realise them. (Such a ranking is established on the basis of evidence like examples (1–3) above, where certain kinds of role seem to win out over others when it comes to certain GFs like subject – see Fillmore 1968 and Jackendoff 1972, p. 43.)

But thematic roles are problematic: firstly, it does not seem possible to come up with a universally appropriate list or ranking of roles (Newmeyer, 2002, 65ff. B. Levin and Rappaport Hovav, 2005, ch. 6; Rappaport Hovav and B. Levin, 2007; Davis, 2011); and secondly, criteria for identifying specific roles cannot be reliably given (Dowty, 1991). Some LFG researchers have therefore objected to the central role played by thematic roles in mapping theories, and tried to take a different approach (one such example is discussed in Section 3.5).

A more lofty goal for mapping theory would be to go beyond descriptive adequacy to seek out some kind of *explanation* for why the patterns are the way that they are. To our knowledge, this question of explanatory adequacy has not been addressed directly in LFG work on mapping theory. Such an explanation will undoubtedly depend on general cognitive properties like "salience" or "prominence", and so necessitate cross-disciplinary work and collaboration with the cognitive sciences outside of linguistics, and with sub-disciplines of linguistics which study the interfaces with cognition more broadly, e.g. information structure (see chapters/InformationStructure) and pragmatics.[4] We feel that linguistics has important insights to offer, and hope that future work in mapping theory will begin to consider this more explanatory angle more seriously. One particularly important focus will be paying greater attention to different morphosyntactic alignment systems which have different means of expressing *grammatical* salience/prominence, as this will allow us to map out the limits of cross-linguistic variation, helping us to see what might stand as a candidates for genuine linguistic/cognitive universals.

3 A critical history of argument structure and mapping theory in LFG

In this section, we offer a selective survey of work in LFG on mapping theory and on the representation of argument structure (usually only insofar as it is relevant to mapping theory, as mentioned above). The proposals discussed here often ask slightly different theoretical questions from one another, or are focused on certain kinds of empirical phenomena over others, which may not make direct comparison particularly illuminating; nonetheless, we draw connections where we can, and show how the insights of

[4]There is very little work on integrating pragmatics into the LFG architecture outside of information structure, but see Falk (2009) and Zymla, M. Müller, and Butt (2015) for some discussion and illustrative work.

one school of thought are built upon or challenged by others. Limits of space mean we have by no means been able to review all of the LFG literature on argument structure and mapping theory. We have instead tried to draw out major strands of research or important theoretical/formal developments. For a survey taking another perspective, see Dalrymple, Lowe, and Mycock (2019, ch. 9), and see the end of this chapter for suggestions of further reading on topics not discussed here.

3.1 Lexical rules

Argument alternations of the sort addressed by mapping theories have been at the heart of work in LFG since the very beginning. The seeds of LFG as a framework can be found in Bresnan's (1978) work on the psychological plausibility of transformational grammars, illustrating how the passive can be profitably viewed as an operation on lexical representations, rather than on phrase-level syntactic structures. Bresnan (1980) presents this analysis in a more recognisably LFG-like form, and extends the approach to the formation of intransitives and middles in English. In this latter paper, lexical items are assumed to possess abstract predicate-argument structures, which characterise "those arguments of a semantic predicate that are open to grammatical interpretation" (Bresnan, 1980, p. 100). Such argument positions are then associated with grammatical functions by various (undiscussed) lexical processes, with the result being a LEXICAL FORM – recognisable as what would become in LFG the SEMANTIC FORM value of a PRED attribute. For example, the lexical form for transitive *read*, as in *John read my letter*, is given in (13) (Bresnan, 1980, p. 116):

(13) read $((\textsc{subj}), (\textsc{obj}))$

Here the first argument, corresponding to the reader, is linked to SUBJ, and the second argument, the thing read, is linked to OBJ. The exact nature of this initial linking of arguments to GFs is not spelled out explicitly, but once these connections are in place, other rules can apply to manipulate these lexical forms, capturing the effect of various argument alternations. For example, intransitivisation is achieved by the following rule (Bresnan, 1980, p. 116):

(14) *Intransitivisation:*
$(\textsc{obj}) \mapsto \varnothing$

Here the argument previously linked to OBJ is instead assigned the special null GF $\varnothing$, which indicates that the argument is existentially bound in the semantics, and is not expressed overtly in the syntax. The application of (14) to (13) results in the lexical form in (15), corresponding to the intransitive form of *read*, as in *John read all night*.

(15) read $((\textsc{subj}), \varnothing)$

The passive version of *read*, as in *The book was read (by John)*, can be accounted for by the rule in (16) (Bresnan, 1982, p. 8):

(16) *Passivisation:*
$(\textsc{subj}) \mapsto \varnothing / (\textsc{obl}_{\textsc{agent}})$
$(\textsc{obj}) \mapsto (\textsc{subj})$

The fact that rules like these apply to lexical forms, which encode grammatical functions, rather than to surface constituent structures means that the same rule can be

used across the languages of the world, with language-specific variations falling out from the rules for c- to f-structure mapping in those languages.[5]

Such rules are taken to be REDUNDANCY RULES (Bresnan, 1990a, p. 638): they are not applied on-line in the process of parsing, but rather describe regular relations between items in the lexicon. In other words, the existence of a lexical form like (17) implies the existence of a corresponding passive form like (18):[6]

(17) read $((\text{SUBJ}), (\text{OBJ}))$

(18) read $((\text{OBL}_{\text{AGENT}}), (\text{SUBJ}))$

In fact, Bresnan (1982, p. 6) advocates the principle of DIRECT SYNTACTIC ENCODING, which states that such alterations of GF assignments can *only* apply in the lexicon, via lexical redundancy rules, and cannot be effected on-line by syntactic rules.

In this early formulation of LFG, the value of the PRED attribute at f-structure was taken to be the whole predicate-argument structure of a lexical item – or, rather, its lexical form. That is, there is no dedicated level of a-structure. What is more, there is no account of how the original assignment of GFs to arguments is accomplished – that is, as Falk (2001b, p. 96) observes, early LFG has a theory of *re*mapping, via lexical rules, but no theory of the initial mapping. This is problematic, since such initial mappings involve a number of generalisations which are totally missed if such linking is merely stipulated (we return to this point in the following section).

Such rules also lack the property of MONOTONICITY, since the original assignments of GFs to arguments are overwritten (i.e. the rules are information-destroying not information-preserving). This is not necessarily a problem in itself: the arguments against non-monotonic rules from the perspective of processing only apply to on-line parsing, so redundancy rules which apply in the lexicon are not affected. However, with the discovery that complex predicates necessitate an analysis whereby argument structures can be assembled in the syntax (Butt, 1995; Alsina, 1996b), it became clear that such processes would have to apply in the syntax too, and so the processing arguments once again become relevant. What is more, non-monotonic rules are formally powerful, and essentially unconstrained: any remapping can be described, some of which are most unnatural in the world's languages (Bresnan, 1990a, 639ff.).[7]

3.2 Classical LMT

Dissatisfaction with the non-monotonicity of the lexical rule approach, especially its unconstrained nature, led to the development of LEXICAL MAPPING THEORY (LMT;

[5] Such a view borrows heavily from the promotion/demotion rules of Relational Grammar (cf. Perlmutter and Postal, 1977).

[6] Bresnan (1980) and Bresnan (1982) presents such rules as directional, so that the active maps to the passive, but they can also be seen as bidirectional, so that the existence of either kind of entry implies the other – this is how it is presented in Bresnan (1990a), for example.

[7] A reviewer notes that in XLE, the computational implementation of LFG (Crouch et al., 2008), such apparently non-monotonic rules are in fact rendered as disjunctive specifications instead, thereby removing the non-monotonicity (later theoretical approaches to mapping adopt this disjunctive approach explicitly, discussed in Sections 3.3 and 3.6 of this chapter). We do not accept that this neutralises the objections to lexical rules just discussed, however. If anything, it highlights them: for effective computational implementation, these rules were replaced by something more tractable. Such a move also does nothing to answer the over-generation issue: arbitrary disjunctions are no less expressive than non-monotonic rules, and so if we expect the formalism to constrain the theory in this way, then the XLE implementation is no improvement. (Of course, there are also good reasons *not* to expect the formalism to constrain the theory in this way – see discussion in Section 3.6.2.)

L. S. Levin, 1986; Bresnan and Kanerva, 1989; Bresnan and Zaenen, 1990), a more principled, more constrained theory of argument realisation. There have been many versions of LMT, varying in more or less profound ways from one another, but we believe there is an identifiably coherent body of research which shares enough fundamental assumptions that it makes sense to view it as a whole. We propose to call this CLASSICAL LMT to distinguish it from later varieties, especially the work of Kibort, reviewed in Section 3.5. Classical LMT is in many senses the "canonical" version of mapping theory in LFG, and is the variety which often appears in textbook presentations of the framework (as in e.g. Dalrymple 2001, 202ff. Falk 2001b, ch. 4, Bresnan 2001, ch. 14, Bresnan, Asudeh, et al. 2016, ch. 14, and Börjars, Nordlinger, and Sadler 2019, ch. 8; see also Butt 2006, pp. 117ff.).

3.2.1 Feature decomposition

In the approach to mapping described in Section 3.1, arguments are associated with fully-specified GFs in the lexicon. If those arguments are realised by different GFs as the result of some alternation, like the passive, the assignments have to be overwritten. In Classical LMT, this is avoided by initially underspecifying the GF with which an argument is associated. This underspecification is achieved by decomposing the GFs into features, where each value of each feature describes a *pair* of GFs (Bresnan and Kanerva, 1989, p. 25). There are two binary features, $[\pm r]$ and $[\pm o]$, where $[\pm r]$ refers to whether a GF is thematically restricted or not and $[\pm o]$ to whether a GF is objective or not (Bresnan and Kanerva, 1989, p. 24). This gives the following cross-classification of the four major grammatical functions:

(19)

	$-r$	$+r$
$-o$	SUBJ	OBL_θ
$+o$	OBJ	OBJ_θ

That is, SUBJ is understood as $[-r, -o]$, OBJ as $[-r, +o]$, OBL_θ as $[+r, -o]$, and OBJ_θ as $[+r, +o]$.[8]

Absent from (19) are those GFs not instantiated by noun phrases, *viz.* COMP and XCOMP. The status of these GFs has been debated in LFG – sometimes they are seen as superfluous, being instead viewed as specialised versions of OBJ and/or OBL_θ. We do not discuss this further here, and instead refer the reader to the relevant literature (Zaenen and Engdahl, 1994; Alsina, 1996b; Dalrymple and Lødrup, 2000; Falk, 2005; Alsina, K. P. Mohanan, and T. Mohanan, 2005; Forst, 2006; Arka and Simpson, 2008; Lødrup, 2012; Patejuk and Przepiórkowski, 2016; Szűcs, 2018). In keeping with most work in LMT, we continue to assume that the four GFs in (19) are the only relevant GFs for mapping.

The necessity of a second object GF OBJ_θ has also been questioned (e.g. Alsina 1996b does without it), but most work in LMT assumes that it is well-motivated. Again, we continue to assume OBJ_θ, and the reader is referred to Börjars and Vincent (2008), Kibort (2008), and Dalrymple and Nikolaeva (2011) for further discussion.

Bresnan and Zaenen (1990, p. 49) claim that the minus features describe the less marked grammatical functions, so that the GFs can be ranked in a partially ordered

[8] If we take this seriously, and such features are assumed to have independent content, then this means that grammatical functions are no longer primitives in the theory; instead, the features are. This claim has been made explicitly in the literature (Butt, 1995, p. 31), though it is also possible to view such feature decomposition as merely descriptive, so that it cross-classifies the GFs but does not formally break them down (Butt, Dalrymple, and Frank, 1997; Findlay, 2016, 298ff.).

MARKEDNESS HIERARCHY. This hierarchy is then referred to in the Classical LMT mapping principles to be discussed below:

(20) *The Markedness Hierarchy:*
SUBJ $>$ OBJ, OBL$_\theta$ $>$ OBJ$_\theta$

SUBJ (two negative feature values) is the least marked GF, at the top of the hierarchy; OBJ$_\theta$ (two positive feature values) is the most highly marked, at the bottom. Since in the middle of the hierarchy OBJ and OBL$_\theta$ are not ranked relative to one another (both have one negative and one positive feature value), the hierarchy is only partially ordered.

Interestingly, the order of GFs in this hierarchy differs from the typologically-motivated hierarchy of GFs which Dalrymple, Lowe, and Mycock (2019, p. 11) present as the standard in LFG (based on the Accessibility Hierarchy of Keenan and Comrie 1977):

(21) *The Functional Hierarchy:*
SUBJ $>$ OBJ $>$ OBJ$_\theta$ $(>$ XCOMP, COMP$)$ $>$ OBL$_\theta$ $(>$ XADJ, ADJ$)$

Notably, OBJ$_\theta$ outranks OBL$_\theta$ in (21), while the opposite is true in (20).

The featural decomposition of the GFs first proposed in Classical LMT has occasionally been challenged from empirical and formal perspectives. If the features are supposed to describe natural classes (e.g. $[-r]$ describes an argument which can alternate between SUBJ and OBJ, such as the internal argument of a transitive verb, via the passive alternation), then they are both under- and over-productive. For example, Alsina (1996b, 29, fn. 9) observes that no conjunction of the features in (19) can describe the very natural class of TERMS or DIRECT GFs, *viz.* SUBJ, OBJ, and OBJ$_\theta$. Nor is there a single feature which describes the class of obliques – instead we must use two features, $[+r]$ and $[-o]$. At the same time, there do not seem to exist any alternations between OBJ$_\theta$ and OBL$_\theta$, i.e. the two $[+r]$ GFs, so this feature describes an unnatural class.

As for formal objections to featural decomposition, Findlay (2016, 298f.) points out obstacles to seeing the feature values as truly constitutive of the GFs within the geometry of f-structures, while Findlay (2020, p. 130) and Asudeh (2021, p. 32) object to the "suspiciously circular" (*ibid.*) definition of the feature $[\pm o]$ in particular: $[\pm o]$ identifies a GF as belonging or not to the set {OBJ, OBJ$_\theta$}, but by virtue of no other property than membership of that set. Despite these objections, however, the atomic features first proposed in Classical LMT remain in one form or another in almost all subsequent work on mapping theory in LFG.

In Classical LMT, such features are used to provide information about the potential syntactic realisation of arguments. A distinct level of a-structure is assumed, consisting of an ordered list of arguments, identified by their thematic role, and associated with a single $[\pm o/r]$ feature. These features are assigned on the basis of various principles which we discuss below.

Arguments within a-structure are ordered according to the their thematic role, following the hierarchy in (22) (Bresnan and Kanerva, 1989, p. 23):

(22) *The Thematic Hierarchy:*
Agent $>$ Beneficiary $>$ Recipient/Experiencer
$>$ Instrument $>$ Theme/Patient $>$ Location

Such a hierarchy is important because of the observation that more "prominent" thematic roles tend to be realised by more "prominent" GFs – in particular, the SUBJ function is usually taken by the the argument highest on the Thematic Hierarchy (Fillmore, 1968; Grimshaw, 1990; Speas, 1990). Though, as noted, the validity of the Thematic Hierarchy has been repeatedly challenged (Newmeyer, 2002, 65ff. B. Levin and Rappaport Hovav, 2005, ch. 6).

As mentioned above, arguments are associated with a $[\pm o/r]$ feature rather than with a fully specified GF, allowing for differences in their final syntactic realisation. The manner of this initial allocation of features has varied, however. Initially, specific roles were taken to be intrinsically linked to particular features, as in e.g. Bresnan and Kanerva (1989, pp. 25–26) or Bresnan and Moshi (1990, p. 168):

(23) *Intrinsic classifications:*

Agent	Theme/Patient	Location
$[-o]$	$[-r]$	$[-o]$

This was based on typological observations about common realisations of these thematic roles across languages. However, later reformulations removed intrinsic linking for all arguments except those bearing Theme/Patient-like roles, for reasons of parsimony and generality (Bresnan and Zaenen, 1990; cf. also Her 2003; Her 2013). Following Bresnan and Zaenen (1990, p. 49), the assignments of features to arguments given in (24) are generally taken as standard (cf. also Bresnan, Asudeh, et al. 2016, p. 331):[9]

(24)

patientlike roles:[10]	θ $\vert$ $[-r]$
secondary patientlike roles:[11]	θ $\vert$ $[+o]$
other roles:	θ $\vert$ $[-o]$

The a-structure of a simple transitive verb like *kick* will therefore be as follows, since there is one patientlike role (marked $[-r]$), and one other role (marked $[-o]$):

(25)

kick	$\langle$	Agent	Patient	$\rangle$
		$\vert$	$\vert$	
		$[-o]$	$[-r]$	

[9] θ is a variable over thematic roles.

[10] Quite what it means to be sufficiently "like" a Patient to be classified as "patientlike" has never been made explicit (cf. Asudeh 2021, p. 32 for expression of this concern).

[11] Where verbs have more than one patientlike role, as in ditransitives, one of the two may be "secondary", in the sense of Dryer (1986). Whether this is the case is a matter of cross-linguistic variation: see e.g. Alsina and Mchombo (1993) and Alsina (2001).

3.2.2 Mapping in Classical LMT

Mapping proceeds according to a few simple rules (Bresnan, Asudeh, et al. 2016, p. 334; cf. Bresnan and Zaenen 1990, p. 51):

(26) *Mapping Principles*:

a. Subject roles:

i. $\begin{matrix}\hat{\theta}\\ |\\ [-o]\end{matrix}$ is mapped onto SUBJ when initial in the a-structure;

otherwise:

ii. $\begin{matrix}\theta\\ |\\ [-r]\end{matrix}$ is mapped onto SUBJ.

b. Other roles are mapped onto the lowest [featurally] compatible function on the Markedness Hierarchy in (20).

The symbol $\hat{\theta}$ denotes whichever argument of the predicate is highest on the Thematic Hierarchy.[12] If this has the feature $[-o]$, and it is the left-most argument on the a-structure list, then it is mapped to SUBJ.[13] Otherwise a $[-r]$ argument is realised as the SUBJ. After this, other arguments are mapped to the lowest, i.e. most marked, GF on the Markedness Hierarchy with which they are featurally compatible.

In addition to the Mapping Principles in (26), there are two other general conditions on mapping. The first is FUNCTION-ARGUMENT BIUNIQUENESS (Bresnan, 1980, p. 112), which requires that each thematic role listed at a-structure corresponds to a unique GF (at f-structure), and, conversely, that each GF corresponds to a unique thematic role. In addition, the SUBJECT CONDITION requires that every predicate have a subject (Baker, 1983; Bresnan and Kanerva, 1989, p. 28).

In the case of *kick* (25), $\hat{\theta}$, the Agent, is marked as $[-o]$, and is initial in the a-structure, so is mapped to SUBJ. The lowest $[-r]$ GF for the Patient to map to is OBJ. So we arrive at the canonical active, transitive argument realisation, as exemplified in e.g. *Abigail kicks Belinda*.

The earliest work in LMT, Bresnan and Kanerva (1989), does not include explicit "Mapping Principles"; instead, intrinsic and default assignments of features to arguments produce various possible mappings, which are then filtered down to the unique solution by Function-Argument Biuniqueness and the Subject Condition (Bresnan and Kanerva, 1989, 28ff.). In the sense that this involves positing fewer rules, it is a simpler theory – but the rules it does include are more specific (i.e. referring to particular thematic roles by name), making it less general overall.

Ditransitives like *give* will have three arguments in their a-structure:

[12] This is also sometimes called the THEMATIC SUBJECT or A-STRUCTURE SUBJECT, and has also been equated with the concept of LOGICAL SUBJECT. Such a notion of "most thematically prominent argument" has been shown to play a role outside of mapping theory, such as in determining the antecedent of a reflexive (Dalrymple, 1993; Joshi, 1993; T. Mohanan, 1994; Manning and Sag, 1999).

[13] The requirement that the argument be first on the a-structure list is to account for raising predicates like *seem*, which include an initial, non-thematic argument that prevents any thematic arguments, such as an Experiencer (as in *It seems **to me** that John is happy*), from being realised as the SUBJ. We will not discuss non-thematic arguments further here; see Bresnan, Asudeh, et al. (2016, pp. 332, 340) and the Further Reading section for more.

(27) *give* ⟨ Agent Beneficiary/Recipient Theme ⟩

Following the usual intrinsic classifications, the Theme, as patientlike, is linked to $[-r]$, and the Beneficiary/Recipient and Agent both receive the "elsewhere" $[-o]$ feature, giving us the following a-structure:

(28) *give* ⟨ Agent Beneficiary/Recipient Theme ⟩
$[-o]$ $[-o]$ $[-r]$

As per the Mapping Principles, the Agent, as a leftmost $[-o]$ $\hat{\theta}$, is mapped to SUBJ. The Beneficiary/Recipient maps to the lowest $[-o]$ GF, which is OBL_θ, while the Theme maps to the lowest $[-r]$ GF, OBJ. This gives us one correct mapping for *give*, illustrated in a sentence like *Peter gave a present to Harriet*.

But of course, there is another way of realising the arguments of a ditransitive like *give*: the dative-shifted version, illustrated in *Peter gave Harriet a present*. Since this involves the same thematic roles, this alternation cannot be derived in Classical LMT without some further stipulation (Kibort, 2008, p. 314). It seems that we can choose to view the Beneficiary/Recipient as patientlike (cf. Toivonen, 2013), in which case it is assigned $[-r]$ by the intrinsic classification rules. Now, English is an asymmetric object language, and so forbids the presence of two $[-r]$ arguments at a-structure (Bresnan and Moshi, 1990, p. 172; Alsina and Mchombo, 1993), which means that the (lower-ranked) Theme must instead be marked $[+o]$, as a secondary patientlike argument, per (24). The Agent receives the "elsewhere" $[-o]$ specification as usual, giving us the following a-structure:

(29) *give* ⟨ Agent Beneficiary/Recipient Theme ⟩
$[-o]$ $[-r]$ $[+o]$

This gives us the double-object version of *give*: the Agent is mapped to SUBJ as usual, then the other arguments are mapped to the lowest compatible GFs, in this case OBJ for the Beneficiary/Recipient (the lowest $[-r]$ GF) and OBJ_θ for the Theme (the lowest $[+o]$ GF). Thus, although Classical LMT can express the different mappings of morphosemantic alternations like the dative shift, it does require the initial stipulation that the Beneficiary/Recipient is patientlike and hence $[-r]$, something which later work has taken issue with (Kibort, 2007; Kibort, 2008).

Argument alternations in Classical LMT are handled by adding extra specifications to arguments – in this way information is only added, not removed, and the mapping principles used to account for the alternations remain monotonic, so that "the computational requirement of monotonicity can be met even in the domain of relation changes" (Bresnan, 1990b, p. 650). These monotonic principles stand in contrast to the lexical rule approach discussed in Section 3.1. The passive, however, involves suppression of the highest thematic role:[14]

[14]For all this preamble, it is not actually clear to us how suppression is supposed to be monotonic as it is standardly presented. Without further stipulation, a contradiction would seem to arise if suppression is applied to a $[-o]$ argument such that part (ai) of the Mapping Principles would otherwise apply. Even if $\varnothing$ is actually taken to be a special GF (which is compatible with $[-o]$), so that after application of passivisation, $\hat{\theta}$ is then fully linked and no longer available for mapping, we still arrive at a contradiction, since there

(30) Passive: $\hat{\theta}$
$|$
$\varnothing$

This means the argument in question cannot be expressed by an argument GF at f-structure (though it can still be expressed by an adjunct like the passive *by*-phrase in English). The a-structure for passive *kicked* is then as follows:

(31) *kicked* $\langle$ Agent Patient $\rangle$
$|$ $|$
$[-o]$ $[-r]$
$\varnothing$

If we now apply the Mapping Principles, we see that principle (ai) cannot apply, and so (aii) is invoked, mapping the Patient argument to SUBJ, and giving us the passive form, e.g. *Belinda was kicked*. It is not clear to us that this operation should count as monotonic, however. Without further stipulation, a contradiction would seem to arise if suppression is applied to a $[-o]$ argument such that part (ai) of the Mapping Principles would otherwise apply: even if $\varnothing$ is taken to be a special GF (which is compatible with $[-o]$), so that after application of passivisation, $\hat{\theta}$ is then fully linked and no longer available for mapping, we still arrive at a contradiction, since there are no exceptions in the Mapping Principles to allow for this possibility – there would be a leftmost $[-o]$ $\hat{\theta}$ which is not linked to SUBJ, in violation of principle (ai). It seems to us that for suppression to make sense as a monotonic operation, the Mapping Principles should be modified to add the rider "provided it is not suppressed" (or "provided it is not linked to $\varnothing$") throughout. Otherwise, it should be conceded that some argument alternations (those that involve suppression) remain non-monotonic.

Setting this formal concern aside, passivisation also correctly applies to ditransitives in both their realisations. For example, suppressing the Agent in the non-shifted version shown in (28) results in the Theme being promoted to SUBJ, by Mapping Principle (aii), since it is a $[-r]$ argument. This gives us the correct passive alternation in (32), where the Beneficiary/Recipient remains an OBL_θ (since this is still the most marked $[-o]$ GF):

(32) a. Peter gave a present to Harriet.
b. A present was given to Harriet (by Peter).

On the other hand, when the Agent is suppressed in the dative-shifted version (29), the Beneficiary/Recipient is promoted instead, since it is now the $[-r]$ argument, and the Theme remains an OBJ_θ (since this is still the most marked $[+o]$ GF):[15]

(33) a. Peter gave Harriet a present.
b. Harriet was given a present (by Peter).

are no exceptions in the Mapping Principles to allow for this possibility: there would be a leftmost $[-o]$ $\hat{\theta}$ which is not linked to SUBJ, in violation of principle (ai). It seems to us that for suppression to make sense as a monotonic operation, the Mapping Principles should be modified to add the rider "provided it is not suppressed" (or "provided it is not linked to $\varnothing$") throughout.

[15] For those dialects where *%A present was given Harriet (by Peter)* is grammatical, something more needs to be said, of course. It is possible the Asymmetrical Object Parameter of Alsina and Mchombo (1993) is not in force in these varieties of English.

Notice that because Mapping Principle (b) requires that an argument be mapped to the *lowest* compatible GF on the hierarchy, the $[+o]$ argument of such double object verbs remains an OBJ_θ in the passive, and is not, for example, "promoted" to an OBJ. That this is the correct result is not at all obvious from English data alone: the usual test for OBJ-hood is the possibility of promotion through passivisation, but we cannot passivise a passive. In the absence of any morphological marking of the distinction between OBJ and OBJ_θ, there is no obvious way to tell which of the two GFs *a present* bears in example (33b). Data from other languages, however, such as the Bantu language Chichewa, support the Classical LMT analysis.

Ditransitive verbs can be formed in Chichewa by applicativisation, and when the applied argument is a Beneficiary, it is assigned a $[-r]$ classification at a-structure, while the Theme is assigned $[+o]$, exactly as in the English double object construction, and resulting in the same GF assignments as we saw above (Alsina and Mchombo, 1993, p. 28). In such Chichewa applicatives, only the OBJ (the Beneficiary) can be indexed by an object marker on the verb, while the OBJ_θ (the Theme) cannot (Bresnan and Moshi, 1990; Alsina and Mchombo, 1993, p. 22):[16]

(34) a. Chitsîru chi-na-wá-gúl-ir-á mphâtso (atsíkāna).
7-fool 7S-PST-2O-buy-APPL-FV 9-gift 2-girls
'The fool bough a gift for them (the girls).'

b. * Chitsîru chi-na-í-gúl-ir-á atsíkāna (mphâtso).
7-fool 7S-PST-9O-buy-APPL-FV 2-girls 9-gift

Now, given the a-structure assignments, we also observe the same passivisation pattern for Chichewa applicatives as for the English double object construction, with the Beneficiary OBJ being promoted to SUBJ (Alsina and Mchombo, 1993, p. 29):

(35) Atsíkāna a-na-phík-ír-idw-á nyêmba.
2-girls 2S-PST-cook-APPL-PASS-FV 10-beans
'The girls were cooked beans.'

Crucially, we now have a diagnostic to identify the GF of the remaining Theme argument: if it is promoted to OBJ, it should be compatible with the presence of an agreeing object marker on the verb; if it remains an OBJ_θ, then the use of the object marker will not be possible. In fact, use of the object marker in this construction is ungrammatical (Alsina and Mchombo, 1993, p. 30):

(36) * Atsíkāna a-na-zí-phík-ír-idw-á (nyêmba).
2-girls 2S-PST-10O-cook-APPL-PASS-FV 10-beans

This incompatibility shows that the Beneficiary argument here must still be an OBJ_θ, not an OBJ, and this therefore motivates the GF ranking in Mapping Principle (b). This evidence was crucial in the development of Classical LMT, but it appears to have been overlooked in later versions of mapping theory: approaches such as those discussed in Sections 3.4 and 3.5 below make the wrong prediction, that the Theme is promoted to OBJ in the passive (see further discussion in those sections).

For reasons of space, we do not give other examples of the many argument alternations, argument-adding or argument-suppressing processes, or interactions between these which have been explored within the vast body of LMT literature. For some

[16] Object NPs indexed on the verb can be omitted, indicated here by parentheses. Numbers signify noun classes; S = subject marker; O = object marker; FV = final vowel.

pertinent examples, see Bresnan, Asudeh, et al. (2016, 334ff.). We will, however, consider one phenomenon which illustrates the advantage of the Classical LMT approach: resultatives.

Resultative predicates can be applied to the objects of transitives (37a), the subjects of passives (37b), the subjects of unaccusative intransitives (37c), but *not* to the subjects of unergative intransitives (37d) (Simpson, 1983; Bresnan and Zaenen, 1990, p. 46):

(37) a. We pounded the metal flat.
b. The metal was pounded flat.
c. The river froze solid.
d. * The dog barked hoarse.

What is the correct generalisation which captures this class of arguments? Clearly it cannot be based on surface grammatical function, since the arguments which can participate include both subjects and objects, though not all subjects. Similarly, the generalisation cannot be given on semantic grounds, e.g. that it is the Theme argument. This is because resultatives can also be applied to non-thematic arguments like so-called "fake reflexives" (38), or "non-subcategorised objects" which do not stand in a direct semantic relation to the main verb (39) (Bresnan and Zaenen, 1990, p. 47):

(38) a. The dog barked itself hoarse.
b. We ran ourselves ragged.

(39) a. The dog barked us awake.
b. We ran the soles right off our shoes.

Rather, the correct generalisation is that these are arguments which are classified as $[-r]$ at a-structure. For the Themes in (37), this follows from them being "patientlike", and therefore marked $[-r]$ by the intrinsic classification rules in (24). At the same time, non-thematic arguments, such as those in (38–39), must be $[-r]$ since they do not bear a thematic role, and so clearly cannot be thematically restricted. Thus, the assumption of a separate level of a-structure, with its own organising principles and features, allows us to give an account of what would otherwise be a puzzling generalisation to explain.

3.3 Butt (1995): complex predicates and elaborated a-structures

The Classical LMT approach treats a-structure as very minimal: it contains an ordered list of arguments, but has no other structure, and contains no semantic information aside from the thematic roles of the arguments. This preference for a formally sparse structure containing minimal semantic information is found in many works on argument structure in the early 1990s within and outside of LFG (e.g. Grimshaw, 1990; Alsina, 1993; T. Mohanan, 1994). By contrast, Butt (1995) represents a markedly different approach: she employs an ELABORATED A-STRUCTURE (Butt, 1995, p. 133), which includes much more structure and much more semantic information. Butt's a-structures are based on Jackendoff's (1990) LEXICAL CONCEPTUAL STRUCTURES (LCSs), but only include the concepts relevant to linking and semantic case marking (Butt, 1995, p. 143).[17] An example of the elaborated a-structure for the Urdu verb *de* 'give' is shown in (40):

[17] Butt's approach is therefore partially in line with the view that a-structure is only relevant insofar as it supports mapping theory, since certain other complexities from Jackendoff's (1990) original formulation are dropped – but not entirely, since it also takes semantic case-marking to be motivated by a-structure properties.

(40)
$$\left[\begin{array}{l}\text{de 'give'} \\ \left[\begin{array}{l}\text{CS}([\alpha], \text{GO}_{Poss}([\ ], \text{TO}[\ ])) \\ \text{AFF}([\ ]^{\alpha},\ ) \\ \text{ASP}(\_\ \_\ \_)\end{array}\right]_{E}\end{array}\right]$$

The inner box is the actual a-structure, and contains three levels. The first two are borrowed from Jackendoff's LCSs: the THEMATIC TIER and the ACTION TIER. The former, the Thematic Tier, describes the lexical meaning of the verb – here that one entity *causes* (CS) *possession* of another to *go* (GO_{Poss}) *to* a third entity (TO). The latter, the Action Tier, describes the relationship between Actor, Patient, and Beneficiary roles – in other words those roles which usually receive structural case. As Butt (1995, p. 137) points out, it can also be thought of as encoding an analogue of Dowty's (1991) PROTO-ROLES. Here the argument labelled α, i.e. the 'giver' (the one causing the transfer of possession) is indicated to be *affecting* (AFF) something else. The second slot of the function AFF is left empty, indicating that there is no true Patient or Beneficiary here (Butt treats the recipient as a simple Goal instead of a Beneficiary). There are also subtypes of the AFF function which provide information about volitionality or conscious choice.

The final tier is the ASPECT TIER. This is not borrowed from Jackendovian LCSs, but is an innovation by Butt. It represents aspectual information: specifically, whether a verb is positively or negatively specified for inception, duration, and/or completion (Butt, 1995, p. 142). The function ASP contains three slots, one for each of these properties, and each can be specified positively, with a '1', negatively, with a '0', or left unspecified, indicated by a '_'. In (40), all three slots are empty, showing that this verb is unspecified for this aspectual information.

Clearly, this conception of argument structure is far more complex than the ordered lists used in Classical LMT. But this complexity is motivated by Butt through its capacity to offer an elegant account of a difficult empirical problem, that of complex predicates. Complex predicates are predicates which behave like single clauses in the syntax, but whose meanings incorporate two semantic heads and which therefore have complex argument structures. (41) gives an example from Urdu (from Butt 1995, p. 35):

(41) anjum=ne saddaf=ko haar banaa-ne
Anjum.F=ERG Saddaf.F=DAT necklace.M.NOM make-INF.OBL
di-yaa.
give-PERF.M.SG
'Anjum let Saddaf make a necklace.'

As Butt points out, in terms of argument structure, the permissive verb *di-yaa* 'let' and the main verb *banaa-ne* 'make' both contribute: although *saddaf=ko* is shared between the two – it is the 'lettee' argument of *di-yaa* and the maker argument of *banaa-ne* – other arguments belong to only one verb: *anjum=ne* is only an argument of *di-yaa* (she is the one giving permission), and *haar* is only an argument of *banaa-ne* (it is the thing being made). What makes these constructions so challenging to analyse, though, is that in terms of syntax, they behave as if the two semantic heads contribute only a single predicate. The sentence in (41) behaves like a single clause with respect to agreement, anaphora, and control (for reasons of space we do not demonstrate this here, but see Butt 1995, pp. 36–43 for detailed evidence and argumentation". So while there

might be separate semantic heads here, in terms of argument structure they are "fused", and form a single predicate. Without the more articulated a-structures Butt proposes, representing this fusion is much more difficult, and potentially less perspicuous.[18]

On Butt's (1995) approach, the light verbs which are used in complex predicates have a-structures which themselves have argument slots for *other a-structures*, labelled as TRANSPARENT EVENTS (E_T), since their internal structure is accessible by the light verb. This allows various kinds of ARGUMENT FUSION to take place, whereby participants of the embedded event are identified with participants of the event described by the light verb (as with *saddaf=ko* in example (41) above). We omit the full details here – see Butt (1995, ch. 5) for more information. The a-structure for the Urdu permissive *de-* 'let' is given in (42) (Butt, 1995, p. 156):

(42)
$$\left[\begin{array}{l}\text{de- 'let'}\\ \left[\begin{array}{l}\text{CS}([\alpha], \text{GO}_{Poss}(\{\ \}_{E_T}, \text{TO}[\ ]))\\ \text{AFF}([\ ]^{\alpha},\ )\\ \text{ASP}(\_\ \_\ \_)\end{array}\right]_{E}\end{array}\right]$$

This is very similar to the a-structure in (40), the only difference being that the first argument of GO_{Poss} has been replaced by a transparent event (indicated by the curly braces and subscript E_T). The letting event is viewed metaphorically as a transfer event, where the thing transferred is the permitted event. This gives some explanation to the fact that both verbs share the same form in Urdu, for example, and shows how the embedded verb contributes to the overall interpretation of the complex predicate. It also allows for the recursive construction of complex predicates which are embedded under more than one light verb.

Butt's (1995) elaborated a-structures differ from other proposals in two important ways: they have a more complex structure than a simple list, and they include a large amount of semantic information. However, Butt (1995, 164ff.) observes that the flat argument structures assumed elsewhere are actually recoverable from her elaborated ones: LCSs, and so elaborated a-structures, express information about the ranking of their arguments. Firstly, everything on the Action Tier outranks everything on the Thematic Tier; secondly, on each tier arguments to the left outrank arguments to the right. This means the empty (argument) slots in an elaborated a-structure can be extracted and represented as a simple list if so desired. This then allows mapping to proceed along standard lines, using some version of the Classical LMT approach (see Butt 1995, ch. 6 for further details).

Where proposals have been made for more articulated a-structures, these generally include only minimal semantic information (in the form of thematic roles), e.g. Butt, Dalrymple, and Frank (1997) (see Section 3.4), or none at all, e.g. the s-structure standins for a-structure of Asudeh and Giorgolo (2012) (see Section 3.6). The motivation for including such rich semantic information in a-structure presented by Butt is that it allows for a better representation of the compositional structure of complex predicates. But with our modular, LFG hats on, we might be sceptical of such a justification, since a-structure is not the level at which to represent compositional semantics (albeit of a limited kind). That should be handled at a level dedicated to meaning, either

[18] Other work on complex predicates and LMT, including Butt's own later work, has tended to eschew the more complex a-structures in favour of the simpler, ordered list representations (e.g. Alsina 1996b; Alsina 1997; Butt 2014). But this leads to enormous difficulty in appropriately formalising the process of predicate fusion, a point which other authors have taken issue with (e.g. Lowe 2016, sec. 2).

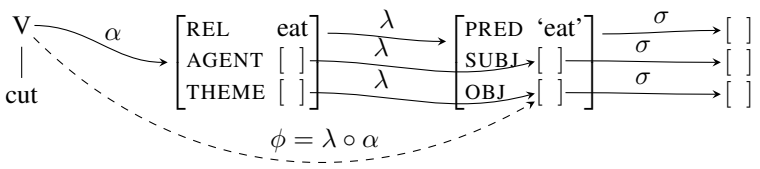
s-structure or in the Glue Semantics component (on Glue, the *de facto* standard way of handling the syntax-semantics interface in LFG, see chapters/Glue; see Findlay 2021 for a brief history of semantics in LFG).[19] This is the view espoused by Lowe (2016) and Lovestrand (2020), who present a different analysis of complex predicates making use of Glue Semantics and the articulated s-structures to be discussed in Section 3.6.

3.4 Butt, Dalrymple, and Frank (1997): Optimal Linking

Butt, Dalrymple, and Frank (1997) represents an important watershed in the treatment of argument structure and mapping theory in LFG: it was the first work to formally incorporate a-structure into the projection architecture, the first to treat linking as harmonising sets of preference constraints (rather than as a process determined by a set of dedicated rules and principles), and also made a number of formal choices and innovations which have carried over into contemporary work on argument structure and mapping theory (e.g. treating a-structure as an attribute-value matrix (AVM), using co-description for expressing linking relations, and treating underspecification by features as a disjunction of GFs – see Section 3.6). Thus, even if the specifics of the proposal's approach to mapping may not have been taken up by the community at large, its overall influence has been significant. In this section, we will outline Butt, Dalrymple, and Frank's (1997) proposal while highlighting these important innovations.

Previous work on argument structure and mapping has either been vague/agnostic about its position in the architecture of the grammar, or has situated it inside f-structure, as (part of) the value of PRED. Butt, Dalrymple, and Frank (1997, p. 1), on the other hand, propose that argument structure forms its own level of representation, a-structure, situated in the projection architecture between c-structure and f-structure:

(43)



(Butt, Dalrymple, and Frank, 1997, 1, their ex. (1))

This positioning is motivated by the complex predicate facts mentioned in the previous section. A-structure must sit before f-structure, since complex a-structures can correspond to simplex (monoclausal) f-structures. The projection functions, as functions, can be many-to-one, but not one-to-many, which means that a-structure must be mapped to f-structure, and not *vice versa*.[20] On the other hand, since complex a-structures can be built from discontinuous pieces in the syntax, and are not necessarily generated in the lexicon, a-structure must be positioned after c-structure, so that information can be passed from the latter to the former.

This does have the effect of breaking up the traditional ϕ mapping from c- to f-structure: it is now the composition of two functions, the α function from c- to

[19] Some may even suggest that the level of representation proposed by Butt (1995) is not argument structure at all, but rather some kind of "event structure" or "semantic structure". However, we have included it in this chapter as an illustration of the differing opinions about how much lexical semantic information should be included in representations of argument structure – a debate which we think is important, and under-discussed in the LFG setting. For one thing, such an enriched a-structure offers the possibility of analysing lexical semantic phenomena such as aspect or Aktionsart, which other, more spartan LFG approaches to a-structure lack any means of doing.

[20] More recent work, however, has reversed this position – see Section 3.6.1.

a-structure, and the λ function from a- to f-structure, i.e. $\lambda \circ \alpha$.[21] Some have seen this as undesirable: for example, Asudeh and Giorgolo (2012) propose a change to the architecture that restores ϕ to its atomic status, and claim this as one of their proposal's advantages (Asudeh and Giorgolo, 2012, p. 71) – but if this is an advantage, we do not see how it can be anything other than an aesthetic one.

A second area where Butt, Dalrymple, and Frank (1997) add formal precision to the account of argument structure and mapping theory in LFG is in the nature of linking itself. What does it mean for an argument to be realised as a GF? This question is not answered in formal terms in earlier work, but Butt, Dalrymple, and Frank (1997, p. 6) make it explicit: since a-structure has been suitably incorporated into the projection architecture, we can express linking as CO-DESCRIPTION (Kaplan, 1995), making use of the α and λ projections to relate arguments at a-structure to GFs at f-structure. For example, to say that a predicate's Agent argument is expressed as its SUBJ GF, we could include the following piece of functional description in its lexical entry (where $*$ refers to the c-structure node bearing the annotation, and $\hat{*}$ to its mother node):

(44) $(\hat{*}_{\alpha}\ \text{AGENT})_{\lambda} = (\hat{*}_{\alpha\lambda}\ \text{SUBJ})$

But of course we generally don't want to associate an argument with a single GF. Instead, Classical LMT associates it with a feature which describes a *pair* of GFs. Butt, Dalrymple, and Frank (1997, p. 6) make this disjunctive meaning of the features explicit: instead of associating an argument with a feature, a disjunction of mapping equations like (44) is given, as in (45):

(45) AGENT *links to* $[-o]$*:*
$(\hat{*}_{\alpha}\ \text{AGENT})_{\lambda} = (\hat{*}_{\alpha\lambda}\ \text{SUBJ}) \vee$
$(\hat{*}_{\alpha}\ \text{AGENT})_{\lambda} = (\hat{*}_{\alpha\lambda}\ \text{OBL}_{\text{AGENT}})$

These intrinsic specifications for particular roles can be universal, like (45) for AGENTs and (46) for THEMEs, or they can be parameterized on a language-by-language basis, as is the case for other roles like LOCATION, GOAL, or INSTRUMENT (Butt, Dalrymple, and Frank, 1997, p. 6).

(46) THEME *links to* $[-r] \vee [+o]$*:*
$(\hat{*}_{\alpha}\ \text{THEME})_{\lambda} = (\hat{*}_{\alpha\lambda}\ \text{SUBJ}) \vee$
$(\hat{*}_{\alpha}\ \text{THEME})_{\lambda} = (\hat{*}_{\alpha\lambda}\ \text{OBJ}) \vee$
$(\hat{*}_{\alpha}\ \text{THEME})_{\lambda} = (\hat{*}_{\alpha\lambda}\ \text{OBJ}_{\text{THEME}})$

Of course, these specifications alone do not determine the final mapping. We turn to the question of how mapping is actually implemented in Butt, Dalrymple, and Frank's (1997) proposal below.

Note that the co-description approach as presented here assumes that a-structure is the same sort of formal object as f-structure (and s-structure), i.e. an AVM, so that we can locate an a-structure via α, then specify a particular argument in that a-structure via its attribute name. Butt, Dalrymple, and Frank (1997) use thematic role labels as these attribute names, and the ranking of arguments according to the thematic hierarchy does play a role in their account of mapping, to which we turn shortly. That said, its role is minor in the core proposal – only surfacing in the requirement that the highest available argument be linked to SUBJ. The analysis of complex predicates also makes use of the

[21] Butt, Dalrymple, and Frank (1997, p. 1) identify ϕ with $\alpha \circ \lambda$ (rather than $\lambda \circ \alpha$), but this must be an error, since α has to be applied before λ, given their architecture.

thematic hierarchy, though, as suggested above, the traditional account of complex predicates is formally problematic (see Lowe 2016, sec. 2), so we might not put too much stock in this. Later approaches have chosen to omit thematic role information from a-structure or its equivalent, instead relegating such information to a separate level of representation (e.g. Falk 2001b; Kibort 2001; Kibort 2007) or to the meaning language (e.g. Asudeh and Giorgolo 2012; Findlay 2016).

So far we have discussed the formal changes proposed by Butt, Dalrymple, and Frank (1997), but perhaps their most significant contribution is at the theoretical level. As they put it themselves (p. 6):

> Our approach departs most radically from the LMT literature in that we do not assume that a-structure roles are deterministically and uniquely linked to grammatical functions via a set of default principles. Instead, we propose a set of preference constraints which impose an ordering on the available linking possibilities; the most preferred possibility or possibilities are chosen.

In essence, their approach rejects the mechanistic, rule-driven approach of Classical LMT, and instead proposes that there is a hierarchy of GFs, with those mappings that realise more highly ranked GFs preferred. The hierarchy they propose is as follows:[22]

(47) $\textsc{subj} > \textsc{obj} > \textsc{obl}_\theta, \textsc{obj}_\theta$

That is, SUBJ outranks OBJ, which in turn outranks $\textsc{obl}_\theta$ and $\textsc{obj}_\theta$, which have the same rank as each other. This means, for each argument, that it is preferable for it to be realised as a SUBJ, or, failing that, as an OBJ, or, lastly, as either an $\textsc{obl}_\theta$ or an $\textsc{obj}_\theta$; the argument will therefore be linked to the highest GF on this hierarchy with which it is compatible, given the disjunctive specifications provided in its intrinsic classification.[23]

Butt, Dalrymple, and Frank (1997) do continue to assume the two inviolable conditions of Function-Argument Biuniqueness and the Subject Condition, but, setting these

[22] Butt, Dalrymple, and Frank (1997, p. 7) claim that the hierarchy in (47) can be recast as a preference for negative-valued features in the classic $[\pm o/r]$ schema:

(i) a. $[-r] > [+r]$
b. $[-o] > [+o]$

But the expressions in (i), which is their (15), do not match the authors' prose description, which only applies (ib) within the $[-r]$ GFs. If we simply take (i) as expressing two independent preference rankings, we get the same partial ordering of GFs along markedness lines described in Section 3.2:

(ii) $\textsc{subj} > \textsc{obj}, \textsc{obl}_\theta > \textsc{obj}_\theta$

Alternatively, if we see (ia) as taking precedence over (ib), then we obtain another ranking, this time a total ordering:

(iii) $\textsc{subj} > \textsc{obj} > \textsc{obl}_\theta > \textsc{obj}_\theta$

It is of course an empirical matter which of these rankings (if any) is correct. But it is perhaps noteworthy that there remains such empirical uncertainty, so that we have at least three different rankings proposed in the literature: Butt, Dalrymple, and Frank's (1997) in (47), the Markedness Hierarchy of Classical LMT (and also Kibort MT – see Section 3.5), and the Functional Hierarchy presented by Dalrymple, Lowe, and Mycock (2019, p. 11) and mentioned above.

[23] Note that this reverses the Classical LMT mapping principle where GFs *lower* down the hierarchy are preferred. One consequence of this is that the current approach makes the wrong prediction about the passives of ditransitives, as mentioned in Section 3.2: the Theme argument will be mapped to OBJ when this GF is made available by promotion of the Beneficiary to SUBJ. See discussion below.

aside, mapping is much more dynamic than in Classical LMT. Rather than a single default role classification for all but the highest-ranked argument, here we have a system in which arguments compete for the highest available GFs. Butt, Dalrymple, and Frank (1997, p. 6) do include a preference for the SUBJ to be linked to the highest available argument on the thematic hierarchy, but crucially this is just a preference, and so is not inviolable.

The final mapping chosen is the one deemed "optimal" in terms of realising the highest number of the most highly ranked GFs, and in terms of satisfying any other preference constraints, such as the subject preference just mentioned, along with not violating Function-Argument Biuniqueness or the Subject Condition. Butt, Dalrymple, and Frank (1997, p. 7) use a numerical system to express the relative weightings of different GFs and of other constraints, but this is not a crucial component of the theory, and any appropriate means of ranking different solutions in terms of a set of preferences could be used – for example, the authors speculate (p. 7) that the proposal could be reformulated in terms of Optimality Theory (Prince and Smolensky, 1993, *et seq.*). Here we present just a few analyses and express the rankings more abstractly.

We start with a simple transitive verb like *cut*. For every argument, the most preferred GF is SUBJ, and given the intrinsic classifications for Agent and Theme in (45) and (46), each of the two arguments of *cut* is actually compatible with SUBJ. But we cannot map both to SUBJ, or we fall foul of Function-Argument Biuniqueness, so we must decide which one to map to SUBJ, and which to map to the next most highly ranked compatible GF. Since, following the thematic hierarchy, the Agent argument of *cut* outranks its Theme argument, the subject preference will be satisfied if we map the Agent to SUBJ but not if we map the Theme to SUBJ, so the former mapping is preferred; the next highest GF compatible with the Theme intrinsic specification is OBJ, and so we end up with the correct outcome whereby the Agent is linked to SUBJ and the Theme to OBJ.

Passivisation is handled by assuming that passive morphology introduces an additional constraint forcing the highest ranked argument to be unrealised by an argument GF (or, equivalently, to be realised by the special GF NULL);[24] Such a realisation always scores lower than realising the argument overtly through a GF, and so in general will never be optimal. But when the presence of passive morphology *requires* this suppression, the previous optimal linking is now rendered invalid. Instead, we are simply interested in realising the remaining argument as the highest compatible GF: in this case, Theme is compatible with SUBJ, and so we obtain the correct passive mapping whereby the Theme is the SUBJ, and the Agent is either unexpressed or expressed via an adjunct *by*-phrase.

Interestingly, certain constructions may have more than one optimal linking, and Butt, Dalrymple, and Frank (1997, 8ff.) argue that this in fact characterises alternations which are motivated by semantic/pragmatic constraints (such as the dative shift) and not by morphosyntactic ones (such as the passive).[25] For example, both realisations of

[24]Butt, Dalrymple, and Frank (1997) assume that the passive *by*-phrase is an ADJunct rather than an $\text{OBL}_{\text{AGENT}}$, which is somewhat at odds with their specification of the intrinsic classification of Agents given above in (45), but is common in the suppression-based view of passivisation, where passivisation is taken to exclude the highest argument from mapping. Kibort (2001) offers a different view, whereby passivisation involves simply adding a further $[+r]$ specification to the highest argument, forcing it to be realised as an OBL_θ if at all – see Section 3.5.2.

[25]However, their distinction does not seem to perfectly match that between meaning-preserving (morphosyntactic) and meaning-altering (morphosemantic) alternations, since they consider the locative inversion to be grouped with the dative shift (as being explained by the presence of more than one optimal linking) and distinct from the passive, when the locative inversion is no more meaning altering than the passive (neither

the dative shift alternation in English have equivalent preference rankings:

(48) [Garak] gave [the datarod] [to Sisko].
SUBJ OBJ OBL_{GOAL}

(49) [Garak] gave [Sisko] [the datarod].
SUBJ OBJ $\text{OBJ}_{\text{THEME}}$

Both involve a SUBJ (linked to the highest argument) and an OBJ, and since OBJ_θ and OBL_θ are equally ranked, the different realisations of the third argument make no odds when it comes to the relative weightings of the two mappings. Therefore both mappings are made available by the grammar, and the choice between them must be determined by other factors, such as lexical preference (the shifted variant is impossible with verbs of Latinate origin, for example) and other communicative considerations (for example, see Bresnan 2007 and Bresnan, Cueni, et al. 2007 for usage-based/probabilistic accounts of the alternation, and Goldberg 1995, ch. 6 on the special meanings associated with the double object construction in English).

A *prima facie* difficulty for the Optimal Linking approach emerges when we consider the passive of such double object verbs. As we discussed in Section 3.2, the Theme argument remains an OBJ_θ in the passive, as shown by the impossibility of a co-indexed object marker on the verb in Chichewa, for example.

(50) [Sisko] was given [the datarod].
SUBJ $\text{OBJ}_{\text{THEME}}$

The Classical LMT framework ensures this outcome by requiring arguments to be linked to the *lowest* GF with which they are compatible. In the Optimal Linking approach, however, being linked to a *higher* GF is more optimal, and so in this case we will predict that the $[+o]$ Theme is promoted to OBJ in the passive, contrary to fact.

(51) [Sisko] was given [the datarod].
SUBJ OBJ

As mentioned above, there is no way to tell the difference in English, but such an approach will incorrectly predict that an object-marker should be grammatical in a sentence like (51) in Chichewa. Thus, without further stipulation, the Optimal Linking approach generates the wrong results for passives of double object verbs.

The specific system for mapping described by Butt, Dalrymple, and Frank (1997) has not been adopted by many subsequent researchers. However, each of the formal innovations discussed here – representing a-structure as an AVM, situating it within the projection architecture, realising linking as co-description, and treating the featural decomposition of Classical LMT as disjunctive specifications of pairs of GFs – has been adopted by more recent work focussed on the formal status of argument alternations and mapping in LFG (Asudeh and Giorgolo 2012; Asudeh, Giorgolo, and Toivonen 2014; Findlay 2016; Findlay 2020), to which we will turn in Section 3.6. Before that, though, we consider a different strand of research which has sought to reassess and augment Classical LMT.

alternation affects truth-conditional semantics, but only alters the information structural prominence of its arguments).

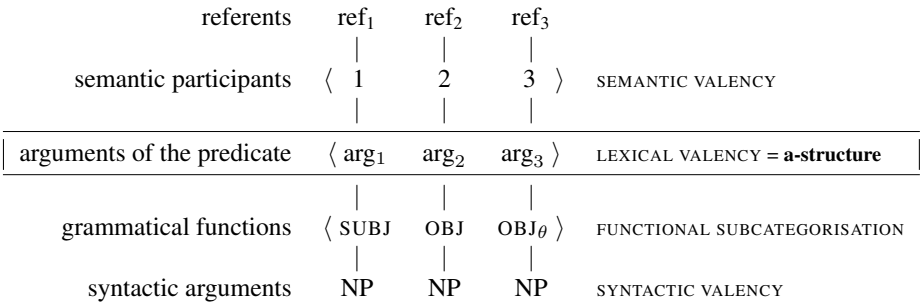


Figure 1: Levels of representation and their connection to a-structure in Kibort MT

3.5 Kibort (2001 *et seq.*): Mapping Theory

In a series of papers, Kibort (2001, 2007, 2008, 2009, 2013, 2014, 2015) develops a refinement and an elaboration of Classical LMT, which she ultimately calls simply MAPPING THEORY (MT), and which we will refer to here as KIBORT MT. This research programme aims to make clearer the interfaces of mapping theory with other modules of the grammar, and to extend the empirical coverage of Classical LMT, in particular by bringing MORPHOSEMANTIC (meaning-changing) alternations more clearly into the fold, alongside the MORPHOSYNTACTIC (meaning-preserving) alternations which were the bread and butter of Classical LMT.

3.5.1 A-structure and its place in the grammar

Drawing on the research which had motivated Classical LMT, Kibort assumes that the grammar ought to operate with a separate, dedicated level of a-structure: as elsewhere, this is represented as a list of (ranked) arguments. Departing from Classical LMT, however, she argues for a separation not only of arguments from the grammatical functions which realise them, but also from the semantic participants which they correspond to, which means that the items that occupy a-structure are *sui generis* objects, distinct both from GFs and from thematic roles.[26] This enables a correct account of the "empty" or "athematic" arguments of raising verbs (in line with analyses of raising verbs by Zaenen and Engdahl 1994, pp. 200, 203 and Bresnan 2001, pp. 309, 317), and – most importantly – is essential in providing a simple and intuitive solution to the problem of morphosemantic operations, i.e. those argument alternations which are associated with more or less substantial changes to the meaning of the predicate and its arguments.

A thoroughgoing mapping theory must take into account all manner of different kinds of information; Figure 1 illustrates the position of a-structure at the heart of this constellation in Kibort MT, representing the typical active voice realisation of the Polish verbal predicate *dać* 'give', where the first argument is interpreted as the giver, the second as the thing given, and the third as the recipient of the giving. Because of the separation of argument positions from semantic participants, arguments at a-structure are involved in two different kinds of mapping: as in Classical LMT, a-structure is connected to the syntax, in terms of the GFs that realise the arguments at f-structure (here SUBJ, OBJ, and OBJ_θ, indicated below the a-structure); but it must also be linked

[26] In fact, this distinction was present in early LFG work (such as Bresnan 1982), and has been argued for by others such as Grimshaw (1988, p. 1), T. Mohanan (1990), Ackerman (1991, p. 12, 1992, 57ff), T. Mohanan (1994, 15ff), Joshi (1993), Alsina (1996b, p. 37), Falk (2001b, p. 105), and Ackerman and Moore (2013, 40ff).

explicitly to the semantics, in terms of the semantic participants to which these arguments correspond (here represented numerically above the a-structure – Kibort MT is agnostic with respect to the exact representation of semantic participants; it may be possible to cash this linking out in terms of s-structure, for example; we return to this briefly below). The former is called ARGUMENT-FUNCTION MAPPING, the latter ARGUMENT-PARTICIPANT MAPPING.[27]

In Kibort MT, the a-structure itself is taken to be a universally available subcategorisation, or valency, frame, an ordered list which represents the relative syntactic prominence of the arguments of the predicate. There is in principle no limit to the number of argument positions, even though the number of the dependents of any particular predicate will of course be limited by practical concerns such as human processing capacity:

(52) $\langle$ arg $>$ arg $>$ arg $>$ arg $>$ arg $\ldots$ $\rangle$

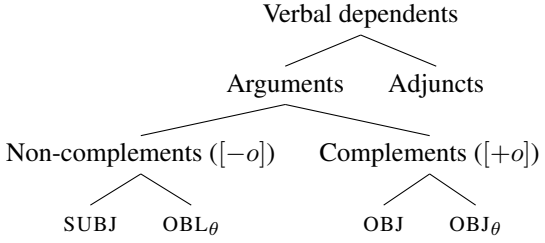
As in Classical LMT, GFs are decomposed by using the two binary features $[\pm o/r]$, and the argument-function mapping potential of each argument position in the a-structure is represented by associating it with a single $+/-$ feature.[28] However, the meaning of these features is reinterpreted in Kibort MT, as follows:

(53)

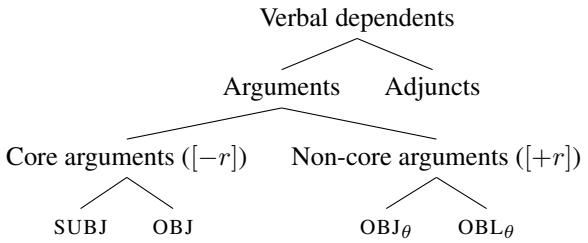
$[-o]$	non-complements	(the "external" argument and oblique arguments)
$[+o]$	complements	("internal arguments" of the predicate)
$[-r]$	core arguments	(subject and object only)
$[+r]$	non-core arguments	(all arguments except subject and object)

This reinterpretation of the features follows a long tradition of linguistic description. Traditionally, the arguments of a predicate are cross-classified in two different ways: into subject and complements; and into core arguments and oblique arguments. MT features can be understood to refer to these same concepts, distinguishing subsets of grammatical functions cross-classified by the features:

(54) a.



b.



[27] In other works by Kibort, these are referred to as "argument-**to**-function/participant mapping", but since the connections are intended to be bidirectional, we omit the preposition here to minimise the procedural implications.

[28] As with Classical LMT, this therefore fails to explicitly take into account the clausal GFs COMP and XCOMP; see discussion in Section 3.2.1.

In addition to this alignment with traditional descriptive work, another advantage of this approach is the lack of reference to semantic/thematic information. This means that semantic and syntactic descriptive units are not mixed up at the same level of representation, and the focus at this level is solely on *syntactic* criteria for the classification of what are after all syntactic functions.[29] By preserving a syntactic characterisation of grammatical functions, Kibort MT also captures the special syntactic status of the secondary object OBJ_θ as a non-core complement argument.

Kibort proposes a universal association of features with argument positions based on cross-linguistic generalisations (which are encoded in the LFG formalism). Namely, predicates may only subcategorise for a single subject (SUBJ) and a single direct object (OBJ), but they may have more than one secondary object (OBJ_θ) or oblique argument (OBL_θ), individual instances of which are distinguished by their subscripts (e.g. $\text{OBJ}_{\text{THEME}}$ vs. OBJ_{BEN}).[30] Given this, and taking the "syntactic prominence" encoded by the order of arguments at a-structure to arise from the standard LFG Functional Hierarchy (introduced above, in Section 3.2, example (21), and repeated here), this gives us the universal subcategorisation frame in (56):

(55) *The Functional Hierarchy:*
$\text{SUBJ} > \text{OBJ} > \text{OBJ}_\theta\ (> \text{XCOMP}, \text{COMP}) > \text{OBL}_\theta\ (> \text{XADJ}, \text{ADJ})$.

(56)

$\langle$	arg_1	arg_2	arg_3	...	arg_4	...	$\rangle$
	$[-o]/[-r]$	$[-r]$	$[+o]$	$[+o]$	$[-o]$	$[-o]$	

The first position, called mnemonically arg_1, corresponds to the canonical subject, and is associated with one of the two features which describe the SUBJ function (it is marked $[-o]$ in unergative predicates, emphasising its non-complement status, and $[-r]$ in unaccusative ones, emphasising its core status).[31] The second position, arg_2, corresponds to the canonical direct object, and is marked $[-r]$ (core). There can only be one each of arg_1 or arg_2. The next position, arg_3, corresponds to the restricted object, and is marked $[+o]$ (complement). There can be multiple positions identical to arg_3. The same is true of arg_4, corresponding to a canonical oblique argument, and marked $[-o]$ (non-complement).

In the representation of any particular predicate, the a-structure contains all and only the selected valency slots for the arguments associated with that predicate. Predicates do not have to select a contiguous series of arguments from the generalised subcategorisation frame. Any semantic participant, including traditional adjuncts such as Instruments or Locations, is assumed to be an argument if it can appear as a core grammatical function (including via alternations such as dative shift or the locative alternation). For example, in *Peter cooked supper for the children*, the lexical valency of this particular variant of the verb *cook* can be illustrated as follows, where arg_1 corresponds to Peter, arg_2 to the supper, and arg_4 to the children:

[29] At least two other LFG linguists have proposed LMT feature sets which make no reference to semantic/thematic restrictions: Alsina (1996b) and Hemmings (2012).

[30] While these functions are often indexed by thematic roles, this is purely for distinctiveness, and has no semantic content: instead of $\text{OBJ}_{\text{THEME}}$ and OBJ_{BEN} we could use other mnemonic labels such as cases (e.g. OBJ_{ACC} vs. OBJ_{DAT}, etc.) or preposition names (e.g. OBL_{TO} vs. OBL_{ON}, etc.), or purely arbitrary labels such as OBJ_1 and OBJ_2. Thus, the retention of the GFs OBJ_θ and OBL_θ does not diminish the syntactically-motivated characterisation of GFs in Kibort MT.

[31] Although the unergative/unaccusative distinction was originally applied only to intransitive predicates (Perlmutter, 1978), subsequent work has extended it to predicates of all valencies: see Kibort (2004, pp. 74–75) for discussion.

(57) *cook* $\langle$ $\underset{[-o]}{\text{arg}_1}$ $\underset{[-r]}{\text{arg}_2}$ $\underset{[-o]}{\text{arg}_4}$ $\rangle$

Note, therefore, that the indices 1, 2 and 4 on the arg position labels do not correspond to an argument count. Instead, by their relative ordering in the frame and by their permanent association with a particular syntactic feature, the indices identify the particular argument positions within the universal valency frame which are in use by the predicate.

3.5.2 Mapping in Kibort MT

What we have considered as mapping so far in this chapter corresponds to "argument-function mapping" in Kibort MT, i.e. the linking of argument positions and GFs. In this section, we describe how this works in Kibort MT, before turning to the other component of mapping in this framework, "argument-participant mapping".

As in Classical LMT, arguments in Kibort MT are associated with a feature that makes them compatible with two different GFs, and mapping therefore consists in determining which of the two (if either) will realise the argument syntactically. Kibort MT diverges from Classical LMT, however, in only having a single Mapping Principle (cf. Her 2013):

(58) *Mapping Principle (Kibort MT):*
The ordered arguments are mapped in turn onto the highest (i.e. *least* marked) compatible grammatical function on the markedness hierarchy. (Cf. Kibort, 2014, p. 267)

The markedness hierarchy referred to here is the one presented above as example (20) in Section 3.2, and repeated below:

(59) *The Markedness Hierarchy:*
$\text{SUBJ} > \text{OBJ}, \text{OBL}_\theta > \text{OBJ}_\theta$

As discussed earlier, this is motivated by treating the $+$-valued mapping features as more marked than the $-$-valued features, so that SUBJ ($[-r, -o]$) is the least marked, OBJ_θ ($[+r, +o]$) the most, and OBJ and OBL_θ lie in the middle (both having one $+$ and one $-$ feature).

To see how the Mapping Principle is applied, let us return to the example of *cook* in *Peter cooked supper for the children*, whose a-structure is repeated below:

(60) *cook* $\langle$ $\underset{[-o]}{\text{arg}_1}$ $\underset{[-r]}{\text{arg}_2}$ $\underset{[-o]}{\text{arg}_4}$ $\rangle$

Arguments are mapped according to their ordering in the valency frame, so arg_1 is mapped first, and is linked to the highest available GF: in this case, SUBJ. The next highest argument position is then associated with the highest compatible grammatical function which is still available; arg_2 is compatible with SUBJ and OBJ, but SUBJ is no longer available (having been linked to arg_1), so arg_2 must map to OBJ. The last argument, arg_4, is compatible with SUBJ and OBL_θ, but since the former is already taken, it is mapped to OBL_θ. Thus, we arrive at the correct mapping for the default, active voice use of this verb, where it subcategorises for a SUBJ (*Peter*), OBJ (*supper*), and OBL_θ (*for the children*). In general, mapping proceeds in this way until all argument positions selected by the predicate are mapped to compatible and available grammatical functions.

Morphosyntactic operations interfere with this default argument-function mapping, but do not affect the lexical or semantic levels of representation of the predicate – that is, they are meaning-preserving (see e.g. Sadler and Spencer 1998). Changes to the default mapping are achieved not by altering any existing information in the valency frame, but by increasing the specification of an argument position and thereby forcing an argument to map to a different grammatical function than the one achieved by default. This preserves monotonicity, as in Classical LMT, but is even more restrictive, since it avoids the use of suppression.

For example, rather than seeing passivisation as suppressing the highest argument at a-structure, as in Classical LMT, Kibort (2001, p. 170) views it as a further specification of arg_1 as $[+r]$, illustrated in (61) for *kick* (cf. (31) above):

(61) $\textit{kick}_{\text{PASSIVE}} \quad \langle \quad \begin{matrix}\text{arg}_1 \\ [-o] \\ [+r]\end{matrix} \quad \begin{matrix}\text{arg}_2 \\ [-r]\end{matrix} \quad \rangle$

In this way, the argument which by default would map to SUBJ is instead fully specified as an OBL_θ, and, as a result, the arg_2, if there is one, becomes the SUBJ. It is assumed by Kibort that OBL_θs are never obligatory, which accounts for the optionality of the Agentive *by*-phrase.[32]

In general, morphosyntactic operations are assumed to involve making arguments more marked, by adding additional $+$-valued specifications:

(62) a. adding the $[+r]$ specification to a $[-o]$ argument
(e.g. passive)

b. adding the $[+r]$ specification to a $[+o]$ argument
(e.g. secondary object preservation: Kibort 2007, p. 268)

c. adding the $[+o]$ specification to a $[-r]$ argument
(e.g. locative inversion: Kibort 2004, 364ff.)

One thing to note about argument-function mapping in Kibort MT is that the Subject Condition of Classical LMT is absent. The motivation for this is that genuinely subjectless predicates are quite common in the world's languages (see Kibort 2006 and Lowe, Molina-Muñoz, and Ruppel 2021 for discussion). For instance, Polish intransitives can be passivised, resulting in a subjectless sentence (Kibort, 2006, 304ff.):

(63) Było codziennie sprzątane (przez firmę).
was.3SG.N every-day clean.PART.SG.N (by company)
'There was cleaning every day (by a company).'

This follows naturally in Kibort MT, where the verb will have the following a-structure, resulting in the first and only argument being mapped to OBL_θ, rather than SUBJ:

(64) $\textit{sprzątać}_{\text{PASSIVE}} \quad \langle \quad \begin{matrix}\text{arg}_1 \\ [-o] \\ [+r]\end{matrix} \quad \rangle$

But of course the original Subject Condition was not proposed on a whim, so how does Kibort MT account for the very strong cross-linguistic preference for subjects? This is

[32] This cannot be the whole story, however, since there are clearly instances of obligatory OBL_θs, as in e.g. *I gave the book *(to my friend)*.

achieved by the altered Mapping Principle: since this requires that arguments map to the *least* marked GF available, instead of the *most* marked as in Classical LMT, it means that the SUBJ will always be the most preferred GF, and so usually *something* will map to it. The only time this will not happen is when the predicate only subcategorises for an arg_3 (assumed not to happen), or when some morphosyntactic operation intervenes, as with the passive. The consequence of this choice, however, is that Kibort MT, just like Butt, Dalrymple, and Frank's (1997) Optimal Linking approach, again makes the wrong predictions about the passive of a double object construction, as mentioned above in Section 3.2 and discussed in relation to Butt, Dalrymple, and Frank (1997) in Section 3.4 – namely, that the Theme argument will be promoted from OBJ_θ to OBJ when the Beneficiary is promoted to SUBJ, since OBJ is less marked than OBJ_θ. As discussed earlier, evidence from Chicheŵa shows that this is the wrong analysis.

We turn now to the other kind of mapping in Kibort MT: argument-participant mapping. Since Classical LMT conflates argument positions and thematic roles, i.e. semantic participants, it is in principle incapable of describing argument alternations where these participants, or their semantic properties, change. By separating out argument positions from semantic participants, Kibort MT allows for a greater degree of flexibility in this domain. Most significantly, the mapping between participants and argument positions can itself be altered. To see why this is important, consider the well-known SPRAY/LOAD alternation (B. Levin, 1993, 50f.), illustrated in (65):

(65) a. Adam sprayed the paint on the wall.

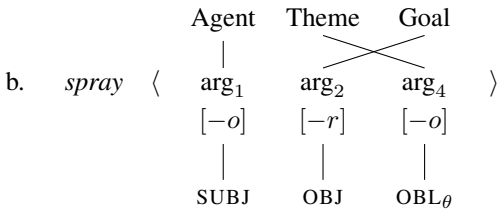
b. Adam sprayed the wall with the paint.

Both alternants here involve the same GFs, namely SUBJ, OBJ, and OBL_θ. The a-structure therefore includes at least the following:

(66) *spray* $\langle$ $\begin{array}{ccc} \text{arg}_1 & \text{arg}_2 & \text{arg}_4 \\ [-o] & [-r] & [-o] \\ | & | & | \\ \text{SUBJ} & \text{OBJ} & \text{OBL}_\theta \end{array}$ $\rangle$

But although the two alternants in (65) are identical in terms of GFs, and therefore seem to have the same a-structure insofar as argument-function mapping is concerned, they are not identical in terms of what arguments those GFs correspond to: in (65a), the OBJ realises the Theme, while in (65b), it realises the Goal. This has semantic implications, since the predicate entails that the participant corresponding to its OBJ, but not to its OBL_θ, is completely affected (i.e. in (65a), the paint is fully used up, while in (65b), the wall is totally covered). Kibort MT addresses this by allowing the two semantic participants (the entity sprayed and the entity sprayed onto) to map onto the argument positions in two different ways, which in turn enables the two participants to be expressed via different grammatical functions.

(67) a. *spray* $\langle$ $\begin{array}{ccc} \text{Agent} & \text{Theme} & \text{Goal} \\ | & | & | \\ \text{arg}_1 & \text{arg}_2 & \text{arg}_4 \\ [-o] & [-r] & [-o] \\ | & | & | \\ \text{SUBJ} & \text{OBJ} & \text{OBL}_\theta \end{array}$ $\rangle$



That is, while morphosyntactic operations affect the argument-function mapping, morphosemantic ones affect the argument-participant mapping.

Although for a human reader it may be easier to track the re-aligned participants in a-structure diagrams if they are represented by thematic role labels, as in (67), thematic roles have long been demonstrated to be unsatisfactory at capturing argument alternations (see e.g. B. Levin and Rappaport Hovav 2005), and suffer from a number of other issues, which were mentioned earlier (e.g. identity criteria are nebulous, and there is no agreed-upon list or ranking of thematic roles). Furthermore, Kibort (2014) argues that neither Dowty-style proto-roles nor feature decomposition attempts are adequate either. In the absence of an adequate and complete representation of lexical knowledge for any language, including the semantic representation of arguments, Kibort MT instead adopts a very minimal representation of semantic participants. In this system, semantic participants are labelled by numbers which identify which arg positions they can map to (Kibort, 2014, 275ff.). For example, the a-structure of *spray* would be augmented as follows:

(68) *spray* ⟨ $\overset{1}{\text{arg}_1}$ $[-o]$ $\quad \overset{24_{\text{THEME}}}{\text{arg}_2}$ $[-r]$ $\quad \overset{24_{\text{GOAL}}}{\text{arg}_4}$ $[-o]$ ⟩

The first semantic participant is labelled 1 since it can only be linked to the arg_1 position, but the other two are labelled 24 since they can be linked to either the arg_2 or the arg_4 position. The subscripts on the semantic participants are purely for distinctness, and have no semantic content.

Argument-participant mapping has no principles beyond stating that participants with label n can be linked to argument arg_n; arguments whose labels contain multiple numbers, like the Theme and Goal in (68), are assumed to bear multiple labels, i.e. each of the Theme and Goal in (68) simultaneously has the label 2 and the label 4. In cases where multiple mappings are possible, Kibort MT predicts that neither is more basic than the other, since there is no preference ranking encoded in the argument-participant mapping. This is certainly right for the spray/load alternation, since there does not seem any reason to assume that one alternant is derived from the other or that one is more basic than the other, especially given that this alternation is unmarked in English (i.e. there is no morphological or syntactic marker in either version).[33]

In adopting this minimal representation of semantic participants, Kibort MT concedes that it can do no more than describe the various argument-participant mapping patterns found in the world's languages, and does not seek to explain them. This is in keeping with taxonomic endeavours such as B. Levin (1993), which offer a wealth of descriptive data, but do not develop a theory of lexical semantics which might begin to say *why* verb classes pattern the way that they do. This may be seen as a deficiency, but

[33]It may be possible to argue that one of the variants is more basic on non-linguistic grounds, e.g. by reference to the relative prominence of cognitive concepts like Figure and Ground, but the strength of Kibort MT is that such a move is not *necessary*, even if it may sometimes be independently motivated.

by placing only very minimal requirements on the representation of semantic participants, Kibort MT leaves the door open to an integration with whatever theory of lexical semantics might be adopted in the LFG architecture. This is very much in keeping with the modular philosophy of LFG.

In sum, Kibort MT offers a mapping theory that on the one hand simplifies, and on the other hand elaborates on Classical LMT. It is simpler in that there is a universal valency frame, a single Mapping Principle, and no mention of thematic roles, but it is more complex in that it tries to more directly take into account other levels of the grammar, and separates out the notion of argument from semantic participant, thus offering new theoretical tools for describing all kinds of meaning-altering operations on lexical valency.

3.6 Asudeh and Giorgolo (2012) and beyond: Distributed Argument Structure

In the final section of our survey, we turn to some of the most recent research on argument structure and mapping theory within LFG, all united by following an architectural proposal of Asudeh and Giorgolo (2012) to do away with a-structure as an independent level of representation in the LFG architecture and to instead make use of a structurally-enriched s-structure. We propose to call this approach DISTRIBUTED ARGUMENT STRUCTURE (DAS), to represent its focus on encoding argument structure/mapping theory facts as distributed throughout the grammar, rather than assuming a specific level of a-structure dedicated to this information.[34] DAS is in many ways still an emerging research programme: there is no canonical or textbook version, and practitioners disagree on a number of points of detail. Space precludes a full exploration of all this diversity, or discussion of all of the important theoretical questions in play; rather, in this section we attempt to draw out the most important formal and theoretical proposals of DAS, and especially those which set it apart from what came before.[35]

One of the most important aspects of DAS is that it builds on the now well-established LFG theory of the syntax-semantics interface called GLUE SEMANTICS (Glue). For much of the development of argument structure and mapping theory research in LFG, there was no canonical theory of the syntax-semantics interface available to appeal to. With the acceptance of Glue into the LFG mainstream around the turn of the millennium, this changed.[36] DAS puts Glue at the heart of its view of argument structure and mapping theory. In particular, it assumes that Glue's concept of RESOURCE SENSITIVITY (Asudeh, 2012, ch. 5) subsumes the traditional LFG principles of Completeness

[34] And also to suggest something of a connection to work in Distributed Morphology (DM; Halle and Marantz, 1993 *et seq.*), with which DAS shares a drive towards modularisation over bare lexical idiosyncrasy. On this connection, see especially recent work in so-called LEXICAL-REALIZATIONAL FUNCTIONAL GRAMMAR (L_RFG), which explicitly borrows concepts from both DAS and DM (Melchin, Asudeh, and Siddiqi, 2020; Everdell et al., 2021; Asudeh and Siddiqi, 2022).

[35] Note that the proposals of Alsina (1993) and Butt (1995) could also be thought of as "distributed" approaches to argument structure in the sense that argument structure there is considered a clausal rather than lexical phenomenon, and so is distributed across multiple words. Here, though, we refer to the fact that argument structure information is distributed across different modules of the grammar.

[36] Although Glue first appeared in the early 90's (Dalrymple, Lamping, and Saraswat, 1993), it was still not well established in the LFG community by the time much of the the work discussed in the earlier sections of this chapter was conducted. The first major collection of Glue work connected to LFG was Dalrymple (1999), and the theory later appeared in Dalrymple's (2001) handbook-style presentation of LFG, as well as the latest reference guide to LFG, Dalrymple, Lowe, and Mycock (2019, ch, 8.5). We cannot include an introduction to Glue Semantics in this chapter for reasons of space, but see the references just cited, along with Asudeh (2022) and chapters/Glue in this volume for further information.

and Coherence, so that PRED features at f-structure no longer contain an argument list. That is, instead of (69a), we have (69b):[37]

(69) a. $\left[\text{PRED } \text{`eat}\langle\text{SUBJ, OBJ}\rangle\text{'}\right]$
b. $\left[\text{PRED } \text{`eat'}\right]$

This creates greater flexibility when it comes to argument realisation, since the same PRED value can now correspond to several different syntactic realisations of its arguments. In the previous conception, each argument array required a separate PRED value (and therefore a separate lexical entry), since PRED values cannot be manipulated in the syntax (cf. the principle of Direct Syntactic Encoding mentioned in Section 3.1, and discussed further in Kaplan and Bresnan, 1982, Bresnan, Asudeh, et al., 2016, sec. 5.2, and Dalrymple, Lowe, and Mycock, 2019, p. 329).[38]

3.6.1 An architecture without a-structure

As mentioned above, the major shared innovation of DAS is an architectural one: the removal of a-structure and its replacement by a connected s-structure. The original motivation for this comes from Asudeh and Giorgolo's (2012) observations about optional arguments. They consider verbs which take optional objects, like *eat* in English:

(70) a. Donatello ate a pizza earlier.
b. Donatello ate earlier.

Here the Theme argument does not need to be expressed in the syntax, although it must still be present in the argument structure, since it remains part of the core relation expressed by the verb (eating events involve something being eaten), and must also be represented at s-structure, since it is interpreted semantically: the truth of *Donatello ate* implies the truth of *Donatello ate something*. This poses a problem for the Butt, Dalrymple, and Frank (1997) architecture described in Section 3.4 and shown in (71), since there is no route through the projection architecture from the a-structure THEME to its corresponding s-structure without going via its f-structure representation, and it appears not to have one.

(71)
$$\begin{bmatrix}\text{REL} & \text{eat}\\ \text{AGENT} & [\ ]\\ \text{THEME} & [\ ]\end{bmatrix} \xrightarrow{\lambda} \begin{bmatrix}\text{PRED} & \text{`eat'}\\ \text{SUBJ} & \left[\text{PRED } \text{`Donatello'}\right]\\ \text{ADJ} & \left\{\left[\text{PRED } \text{`earlier'}\right]\right\}\\ \text{TENSE} & \text{PAST}\end{bmatrix} \xrightarrow{\sigma} \begin{bmatrix}[\ ]\\ [\ ]\\ [\ ]\end{bmatrix}$$
(with λ also mapping THEME to SUBJ, and σ mapping SUBJ and ADJ to the s-structure)

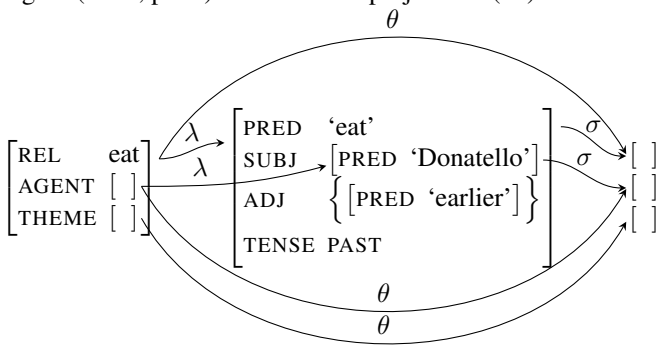
[37] The idea of using linear logic's resource sensitivity to account for Completeness and Coherence goes back to the very first Glue paper (Dalrymple, Lamping, and Saraswat, 1993), and was noted again by Dalrymple, Lamping, Pereira, et al. (1999), Kuhn (2001), and Asudeh (2012, 112ff.), though it didn't find its way into more mainstream LFG work until the advent of DAS.

[38] One oft-noted potential problem with viewing Completeness and Coherence as reducible to semantic resource sensitivity is expletive arguments, i.e. syntactic arguments which do not correspond to semantic ones. Since, by hypothesis, they make no semantic contribution, they will not be required by constraints of semantic resource sensitivity, even though they *are* required for grammaticality. As Asudeh (2012, p. 113) points out, however, this is far from an insurmountable problem, and there are a number of potential solutions (including rejecting the idea that expletive arguments are semantically empty in the first place – see Bolinger 1977). We do not address this issue further here, however.

We might therefore be tempted to posit an unpronounced OBJ attribute at f-structure corresponding to the Theme, but there is empirical evidence against this (Asudeh and Giorgolo, 2012, p. 71). For example, this putative null pronoun cannot antecede another, subsequent pronoun:

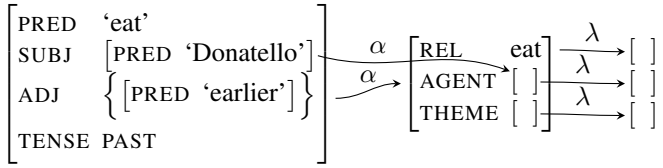
(72) a. Donatello ate a pizza, but it turned out to be Raphael's.
b. * Donatello ate, but it turned out to be Raphael's.

Given this, we are forced to propose a new function which projects directly from a-structure to s-structure (i.e. it is not simply the composition of σ and λ); Asudeh and Giorgolo (2012, p. 70) call this the θ projection. (73) shows this new situation:.

(73)


This move adds formal complexity to the grammar (a whole new projection function) and also adds indeterminacy: when an element of a-structure *is* expressed at f-structure, there are now two ways of reaching its s-structure – one via $\sigma \circ \lambda$ and one via θ directly. Even if this solves the problem of unexpressed arguments, it is a formally unhappy scenario to be forced into.

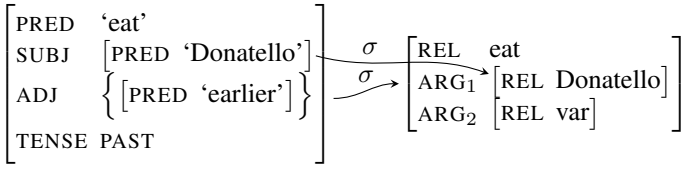
One way to escape this conclusion would be to change the location of a-structure in the grammar: if it were after f-structure, the problem would not arise, since the λ function would now be from a- to s-structure, and we would have no need of the new θ function. (74) shows this alternative view of the architecture (where the σ mapping from f- to s-structure is complexified rather than ϕ):

(74)


As Findlay (2016, p. 308) points out, such a move has some conceptual motivation even aside from the empirical problem of optional arguments. To the extent that a-structure is viewed as an interface between (lexical) semantics and syntax, its position in the Butt, Dalrymple, and Frank (1997) architecture – between two levels of syntax – is anomalous. The architecture in (74), by contrast, remedies this, and puts a-structure between a level of syntax and one of semantics.

But now our attention is drawn to a potential redundancy: s-structure is itself supposed to be an interface level between syntax and semantics, acting as a syntactically-derived scaffold on which the linear logic of Glue Semantics can operate to control semantic composition. If a-structure is also fulfilling this function (by relating GFs to the thematic roles they play in the meaning), then we don't need both levels of representation. Asudeh and Giorgolo (2012) do not entertain the alternative architecture

shown in (74), but they reach the same conclusion: we only need one level to represent this interface between syntax and semantics, and it should be post-f-structure. They call this s-structure, but augment the standard, disconnected representation of s-structure so that instead of the s-structures for the arguments being separate from the s-structure for the clause (and from each other), they are instead embedded inside it, much like Butt, Dalrymple, and Frank's (1997) a-structures. This is shown in (75):

(75)


Ultimately, what name we give to this new connected structure is largely arbitrary; Asudeh and Giorgolo (2012) call it s-structure since they continue to use it as part of the linear logic component of Glue Semantics meaning constructors, but really it has a lot in common with Butt, Dalrymple, and Frank's (1997) a-structure as well, being internally structured/connected and expressing the predicate-argument structure of the clause. What is more, later developments have sought to imbue this new, connected s-structure with additional information about aspect, tense, or event structure (see e.g. Lowe 2014 or Lovestrand 2018), thereby incorporating information from Jackendovian LCSs, some of which was also present in Butt's (1995) elaborated a-structures. For consistency with work in DAS, we will continue to call them s-structures here.

The exact content of these s-structures is subject to ongoing research (see below), but such structures are assumed to at least include a REL attribute identifying the semantic relation expressed (cf. Asudeh, Dalrymple, and Toivonen, 2013, p. 24), and potentially several numbered ARG attributes, e.g. ARG_1, ARG_2, for each of that relation's arguments.[39] These ARG attributes are used instead of thematic role information, since DAS generally makes use of a neo-Davidsonian meaning language (Parsons, 1990) such that thematic role information is expressed directly in the semantics – i.e. instead of (76a), the meaning of *eat* is expressed by (76b) – and so it would be redundant to also encode this information in s-structure.

(76) a. $\lambda x \lambda y \lambda e.\mathbf{eat}(e, x, y)$

b. $\lambda x \lambda y \lambda e.\mathbf{eat}(e) \wedge \mathbf{agent}(e, x) \wedge \mathbf{theme}(e, y)$

This has the additional benefit of relegating thematic roles to the meaning language rather than making them part of the meta-language of the grammar itself. There they can be treated as abbreviations for whatever sets of semantic entailments we take them to encode (*à la* Dowty 1991), with whatever level of granularity is required, leaving the grammar itself free of the nebulous notion of thematic role.

Quite what the ARG labels actually do signify has been a subject of disagreement, however. They were originally intended as arbitrary labels merely to achieve distinctness at s-structure, but Findlay (2016) imbues them with meaning, identifying them with the numbered arg positions of Kibort MT (see Section 3.5.1), a view adopted by others (e.g. Asudeh, Giorgolo, and Toivonen 2014; Lowe 2016; Lovestrand 2018;

[39] Asudeh and Giorgolo (2012) use REL only for predicates, and leave argument s-structures as "empty" AVMs (see below). Lovestrand (2018, ch. 8.3) and Findlay (2020, 135f.) generalise the presence of REL to argument as well as predicate s-structures, and Findlay (2020, p. 144) proposes to use "var" as the REL value for unexpressed/suppressed arguments.

Lovestrand 2020). Findlay (2020), however, argues for a return to the view where these labels have no significance in and of themselves.

In fact, the DAS research programme has proven a useful opportunity to clarify the nature and function of s-structure in general, something which has long been unclear in LFG. Originally (e.g. in Halvorsen 1983 or Halvorsen and Kaplan 1988), s-structures were themselves meaning representations, but with the advent of Glue Semantics they came to have a secondary, somewhat less well-defined role, being merely "put in correspondence" with meanings (Dalrymple, Lamping, Pereira, et al., 1999, p. 11), and often appearing in analyses simply as empty AVMs ('[ ]') – with a promise that this was just a stand-in for a more elaborated structure. But until recently, proposals for that elaboration were largely non-existent (see Findlay 2021, sec. 20.3 for an overview and some discussion). The advent of the connected structures advocated by Asudeh and Giorgolo (2012) has spurred on researchers to fill in these empty AVMs, and to treat s-structure as the proper locus of grammatically-relevant semantic information (a trend already started by Dalrymple and Nikolaeva 2011, although see Findlay 2021, p. 350 for criticism of some of their suggestions), with much ongoing research into what sorts of properties might be best represented here.

Overall, then, and despite some of the marketing,[40] DAS is best seen not as a rejection of argument structure, but merely as a rationalisation of the LFG architecture: instead of having two levels, a-structure and s-structure, the latter of which is rather informationally impoverished, we have a single level of representation which shares properties of both.[41]

3.6.2 Mapping in DAS

DAS provides a set of tools which can be used to formalise a variety of different theoretical approaches to mapping theory. In this section we illustrate these tools via application to a simple example, that of optionally transitive *eat*. A first pass at a lexical entry is given in (77):[42]

[40] Findlay (2016), for example, should not really be entitled 'Mapping theory without argument structure' but rather 'Mapping theory without a-structure (but with a connected s-structure that represents some of that information instead)'.

[41] The observant reader may be entertaining an architectural concern at this point: earlier, in Section 3.4, we presented evidence that a-structure belonged between c- and f-structure by drawing on the facts of complex predicates: a complex a-structure can correspond to a simplex (monoclausal) f-structure, and so we need the former to precede the latter in the projection architecture in order to retain the functional nature of the projection relations. However, in the new architecture, the connected s-structure which represents predicate-argument structure comes after f-structure, so we appear to be in trouble. Two solutions to this puzzle have been proposed. Lowe (2016) gives the first analysis of complex predicates in DAS, and argues that they should be given a flat s-structure (in contrast to the articulated a-structures usually assumed), representing their complexity in the meaning language instead. This avoids any problems arising from having a flat f-structure, since it is no longer required to subsequently project a more articulated s-structure. Alternatively, Lovestrand (2020) proposes to give complex predicates articulated f-structures after all, which means a complex s-structure is also possible without losing the functional nature of σ. There are empirical shortcomings with both of these approaches, but they fare no worse than existing, non-DAS approaches, and serve to illustrate how the apparent monoclausality of complex predicates does not force us to assume an articulated a-structure which precedes f-structure in the projection architecture.

[42] The meaning constructor mentions ($\uparrow_\sigma$ EVENT), but this does not need to appear at s-structure since it is not directly consumed (Findlay, 2021, p. 352).

(77) *eat* V $(\uparrow \text{PRED}) = \text{'eat'}$
$(\uparrow_\sigma \text{REL}) = \text{eat}$

$(\uparrow \text{SUBJ})_\sigma = (\uparrow_\sigma \text{ARG}_1)$
$(\uparrow \text{OBJ})_\sigma = (\uparrow_\sigma \text{ARG}_2)$

$\lambda x \lambda y \lambda e.\mathbf{eat}(e) \wedge \mathbf{agent}(e, x) \wedge \mathbf{theme}(e, y) :$
$(\uparrow_\sigma \text{ARG}_1) \multimap (\uparrow_\sigma \text{ARG}_2) \multimap (\uparrow_\sigma \text{EVENT}) \multimap \uparrow_\sigma$

The first two lines provide the PRED value along with a value for REL at s-structure.[43] The next two lines provide very basic mapping information. Just like in Butt, Dalrymple, and Frank (1997), this is accomplished by co-description: the functional description associated with the verb specifies how its GFs are related to their s-structures via the σ projection. Here the SUBJ is linked to ARG_1, which in the semantics corresponds to the variable x, the Agent; and the OBJ is linked to ARG_2, which corresponds to y and the Theme. GFs are linked to thematic roles, as in other versions of LMT, but this time only indirectly (akin to Kibort's separation of argument-function mapping and argument-participant mapping – see Section 3.5).

In (77), only one possible mapping is encoded. If we wish to retain the same meaning constructor across diathesis alternations, which seems logical since morphosyntactic alternations like the passive are thought not to alter truth-conditional meaning, then these equations are too rigid, and we require a more flexible mapping arrangement to accommodate diatheses. For example, if this verb was passivised, then ARG_2 would correspond to the SUBJ, and ARG_1 would either not be expressed at all or would surface as an $\text{OBL}_{\text{AGENT}}$. In other approaches, this is captured by identifying each argument with a single $[\pm o/r]$ feature, which restricts but does not uniquely determine the GFs it can be realised as. As in Butt, Dalrymple, and Frank (1997), DAS replaces feature decomposition by explicit disjunctions over GFs. Findlay (2016, p. 299) uses abbreviations to capture the traditional features:

(78) a. MINUSO $\equiv$ $\{\text{SUBJ}|\text{OBL}_\theta\}$
b. PLUSO $\equiv$ $\{\text{OBJ}|\text{OBJ}_\theta\}$
c. MINUSR $\equiv$ $\{\text{SUBJ}|\text{OBJ}\}$
d. PLUSR $\equiv$ $\{\text{OBL}_\theta|\text{OBJ}_\theta\}$

Now we can replace the mapping equations in (77) with (79), which is equivalent to (80), and so allows for both the active transitive realisation seen in (77) and the long passive argument realisation where the Agent is an $\text{OBL}_{\text{AGENT}}$ and the Theme is the SUBJ:

(79) $(\uparrow \text{MINUSO})_\sigma = (\uparrow_\sigma \text{ARG}_1)$
$(\uparrow \text{MINUSR})_\sigma = (\uparrow_\sigma \text{ARG}_2)$

(80) $(\uparrow \{\text{SUBJ}|\text{OBL}_\theta\})_\sigma = (\uparrow_\sigma \text{ARG}_1)$
$(\uparrow \{\text{SUBJ}|\text{OBJ}\})_\sigma = (\uparrow_\sigma \text{ARG}_2)$

[43] The current status of PRED and REL in LFG is not settled: many if not all of the important functions of PRED have been taken over by Glue Semantics (Andrews, 2008), and REL really has no substantive role in the theory (Lovestrand 2018, 169ff. although see Lowe 2014). They also seem to both express the same information in (77), which adds a degree of redundancy to the grammar. Nevertheless, they at least serve to help distinguish different f- and s-structures, as well as making the representations more readable. We will have no more to say about them here.

By using explicit disjunctions over GFs, we sidestep any formal issues arising from seeing GFs as decomposable into features (as discussed in Section 3.2), and simply represent the most significant empirical claim of the feature-based approach – that GFs can be grouped into natural classes (whether the $[\pm o/r]$ classification is the correct way of grouping them is orthogonal to this broader claim). It has been objected that this use of disjunctions makes DAS somehow more arbitrary or less well motivated than earlier approaches, since we could have just as easily written a different set of disjunctions in (78). Such an objection is misplaced for two important reasons, however. Firstly, it purports to contrast the arbitrariness of the disjunctive approach with the theoretical motivation of the feature-decomposition approach. But this is only true to the extent that the features used in the latter have independent motivations. While a case could be made for $[\pm r]$ on these grounds (one could imagine an independent criterion for determining semantic restrictedness), as we mentioned in Section 3.2, this seems not to be the case for $[\pm o]$, which has no content other than identifying the two object functions OBJ and OBJ_θ, and whose definition is therefore circular. Given this situation, we take the use of the explicitly "arbitrary" mechanism of disjunction in DAS to be an advantage over the classical approach, since DAS wears its arbitrariness on its sleeve rather than concealing it behind a veneer of theoretical motivation.

Secondly, and much more significantly, such an objection misses the crucial distinction between formalism and theory. The formalism *itself* need not be expected to say anything about what natural groupings of GFs occur in the world's languages. Rather, the formalism gives us tools for making explicit claims about such things – and it is those claims which constitute the theory. As Pollard (1997, p. 9) puts is, "it is the theory that imposes the constraints, not the language in which the theory is expressed". So, although we could've written different disjunctions in (78), it is precisely in writing one set of expressions rather than another that we make a theoretical claim. This claim may turn out to be true or false, but if it is false, we would prefer to be able to use the same familiar tools to express a different, revised hypothesis, rather than have to throw away our tools entirely because they have been over-engineered to fit one particular view of reality. Once again, therefore, we see this property as being an advantage of the DAS approach. As an example, consider the objection by Alsina (1996b, 29, fn. 9), noted in Section 3.2, that the traditional $[\pm o/r]$ features cannot be used to describe the natural class of terms, or direct GFs, i.e. SUBJ, OBJ, and OBJ_θ. He instead proposes a different classification using the features [±subj/obl], where $[-\text{obl}]$ describes the terms (Alsina, 1996b, pp. 27–30). In the traditional view, this approach and the Classical LMT approach are simply incommensurable: they represent two different formalisms which contain different primitive elements. But in the DAS approach, both can be expresed in the *same* terms – compare (78) and (81) – thereby highlighting their status as competing theoretical claims rather than as totally distinct formal approaches.

(81) a. $\text{MINUSSUBJ} \equiv \{\text{OBJ}|\text{OBJ}_\theta|\text{OBL}_\theta\}$
b. $\text{PLUSSUBJ} \equiv \text{SUBJ}$
c. $\text{MINUSOBL} \equiv \{\text{SUBJ}|\text{OBJ}|\text{OBJ}_\theta\}$
d. $\text{PLUSOBL} \equiv \text{OBL}_\theta$

It is an empirical matter which of these analyses is correct, and we should not generally expect the formalism to adjudicate on empirical matters. Rather, the theory which we develop in using that formalism is what we expect to align with the facts.

Returning to our *eat* example, we still need to account for the short passive, where the Agent is unexpressed. For this, we need a way of saying that a semantic argument

does not correspond to any GF at f-structure. We do this by stating that the inverse of the σ mapping from f- to s-structure is empty, as in (82):

(82) $(\uparrow_\sigma \text{ ARG}_1)_{\sigma^{-1}} = \varnothing$

Since these equations are getting quite complex, we can abbreviate them in more perspicuous templates (Findlay, 2016, pp. 319, 321):[44]

(83) $\text{MAP(D,A)} \equiv (\uparrow \text{D})_\sigma = (\uparrow_\sigma \text{A})$

(84) $\text{NOMAP(A)} \equiv (\uparrow_\sigma \text{A})_{\sigma^{-1}} = \varnothing$

(83) says that the GF or disjunction of GFs D is mapped to the s-structure argument A, while (84) says that the s-structure argument A has no GF correspondent at f-structure.[45] These templates can then be combined in a new pair of mapping equations for our *eat* lexical entry, to replace (79):

(85) $\{@\text{MAP(MINUSO, ARG}_1)|@\text{NOMAP(ARG}_1)\}$
$\{@\text{MAP(MINUSR, ARG}_2)|@\text{NOMAP(ARG}_2)\}$

That is, for each argument, either it is mapped to one of its two compatible GFs, or it is not expressed at all.

Of course, if this is all that is said, then we will massively overgenerate. For example, we cannot omit arguments freely, as implied by (85), and not all combinations of GFs are attested: there are four ways of resolving the MINUSO and MINUSR disjunctions in these equations, but only two of them are valid argument realisations – and each of those only in a particular voice (for example, we cannot have the Agent as OBL_θ and the Theme as SUBJ in the active voice: **A pizza ate by Donatello*). In fact, several of the erroneous possibilities are ruled out without further stipulation: we cannot have both arguments realised as SUBJ, for example, since σ is a function, and cannot map one GF to two different arguments.[46] And optionality of arguments is only accommodated insofar as the grammar provides some other means of handling the semantic dependency on that argument in the verb's meaning constructor. If we simply omit arguments willy-nilly, there will be a resource deficit and no valid Glue proof will be possible. Passive morphology is taken to provide the following optional meaning constructor, for example (Asudeh and Giorgolo, 2012, p. 75), which existentially closes the dependency on the first argument, thus allowing it to remain unexpressed:

(86) $\left(\lambda P.\exists x[P(x)] : [(\uparrow_\sigma \text{ ARG}_1) \multimap \uparrow_\sigma] \multimap \uparrow_\sigma\right)$

Nevertheless, there is still a choice to be made, since both mappings are made available in each voice, when in fact only one is possible:

(87) *Active*

a. Donatello ate a pizza (SUBJ:ARG_1, OBJ:ARG_2)

[44] On templates, see Crouch et al. (2008), Dalrymple, Kaplan, and King (2004), and Asudeh, Dalrymple, and Toivonen (2013) and [77ff.]chapters/CoreConcepts in this volume.

[45] One problem with the NOMAP template is that in the event an argument is not expressed syntactically, nothing will ensure its presence at s-structure. Findlay (2020, 135f.) argues therefore that existential constraints must accompany the introduction of each argument, but since other work has not assumed this, we continue with the simpler approach in the text.

[46] This removes the need for one part of Function-Argument Biuniqueness as a separate principle of the grammar.

b. * A pizza ate by Donatello (SUBJ:ARG$_2$, OBL$_\theta$:ARG$_1$)]

(88) *Passive*

a. A pizza was eaten by Donatello. (SUBJ:ARG$_2$, OBL$_\theta$:ARG$_1$)

b. A pizza was eaten. (SUBJ:ARG$_2$, $\varnothing$:ARG$_1$)

c. * Donatello was eaten a pizza. (SUBJ:ARG$_1$, OBJ:ARG$_2$)

d. * Was eaten a pizza. ($\varnothing$:ARG$_1$, OBJ:ARG$_2$)

How do we decide the final mapping in each case?

The answer is that this will depend on the particular version of mapping theory being implemented using the tools of DAS, and so we will not explore the question further here. In practice, most work in DAS adopts what has been called KIBORT-FINDLAY MAPPING THEORY (KFMT; cf. Asudeh, Giorgolo, and Toivonen 2014, p. 75), which implements a version of Kibort MT (or at least the argument-function mapping component – see Section 3.5). However, to do so it imbues the ARG attribute labels at s-structure with specific meanings: they are seen as equivalent to Kibort's numbered arg positions (with some restrictions, so that there cannot be multiple ARG$_3$s or ARG$_4$s, for instance – see Findlay 2016 for the full details). In fact, this tying of the formalism to a particular theory is quite unnecessary: Findlay (2020) demonstrates how it is possible to implement the same mapping theory while retaining arbitrary labels for s-structure attributes, by slightly enriching the tools of DAS. This enables a totally modular perspective on questions of mapping theory, whereby the same formal tools can be used to express a variety of different theoretical approaches.

Formalisation has generally not been a prominent concern in the field of argument structure and mapping theory research in LFG (although there are computational implementations of Classical LMT in XLE). DAS offers a set of tools for formalising a variety of different theoretical approaches, and this is a useful contribution. However, on its own this might be seen as rather a rarefied gain. Far more compelling would be improvements in empirical coverage or theoretical explanation.

The DAS approach offers some hope in this direction too. Because it treats information about mapping and about semantics as the same kind of object, *viz.* pieces of functional description, this means they can be bundled together in templates, expressing their co-dependence and allowing a much more "high resolution" version of mapping theory (Asudeh, 2021), which can rely on far more information than just the thematic roles played by arguments or their ranking in some argument hierarchy – in particular, this could include detailed lexical semantic information, as in the approach of Butt (1995), which could perhaps be incorporated into the new enriched s-structure.[47] This might also offer a means of filling the gap in Kibort MT's representation of semantic participants, and opens the way to a more explanatory theory of argument-participant mapping more generally.

Another promising area of research made possible by DAS is the idea of incrementally bundling up mapping templates into more complex valency templates (as employed in e.g. Asudeh and Giorgolo, 2012; Asudeh, Giorgolo, and Toivonen, 2014; Findlay, 2020), which, coupled with the notion of an inclusion hierarchy between templates (see especially Asudeh, Dalrymple, and Toivonen, 2013, 17ff.), suggests the

[47] One potential objection is that this mapping theory framework is now basically unconstrained: it can rely on literally *any* piece(s) of information that can be encoded in LFG's description language. But this is perhaps as it should be: an "overly" expressive formalism is perfectly normal in scientific research – the theory is what makes interesting claims about the nature of reality, not the formalism used to express it, as discussed above.

possibility of a mapping theory based purely on a richly structured and hierarchical lexicon, along the lines of Davis and Koenig (2000), which therefore avoids the (sometimes disturbingly procedural) mapping principles of other versions of mapping theory in LFG. This potential has yet to be fully explored, though Przepiórkowski (2017) has pointed the way.

4 Conclusion

New approaches to argument structure and mapping theory phenomena were at the heart of what gave rise to LFG as a separate approach to linguistic theory in the first place: Bresnan's (1980, 1982) observations about the lexical character of argument alternations and the benefits afforded by separating out lexical predicate-argument structures from surface syntactic structures were what laid the foundations for LFG's lexicalist, modular view of the grammar. At the same time, though, the formal status of argument structure and mapping theory within the LFG architecture has often been unclear and imprecise, and the initial use of lexical rules to capture alternations went against the otherwise consistent monotonicity of the framework (Bresnan, 1990a). This left a slightly odd tension: the core *theoretical* motivations for LFG were not terribly compatible with the *formal* framework of LFG which emerged. The advent of (Classical) LMT successfully alleviated the need for lexical rules,[48] and some later research (Butt, Dalrymple, and Frank 1997, Asudeh and Giorgolo 2012, and subsequent work in Distributed Argument Structure) has focussed on placing these insights on a more robust formal footing, thereby attempting to resolve the tension.

At the same time, empirical work has continued apace, producing many new observations which have challenged the theory of argument structure and mapping in significant ways. The crucial work on complex predicates of Alsina (1993), Butt (1995), and others (see e.g. Alsina, Bresnan, and Sells 1997; Andrews and Manning 1999) forced a serious reanalysis of mapping from being a lexical to a clausal phenomenon. The correct analysis of double object constructions (Bresnan and Moshi, 1990; Alsina and Mchombo, 1993; Alsina, 1996a) also continues to be debated (see e.g. Kibort 2008). And meaning-changing, morphosemantic alternations have also been brought more and more into the fold of mapping theory (Kibort, 2007). Work in the spirit of Kibort MT has been led by the richness and complexity of the data to propose a much more complex and articulated view of a-structure, making explicit many of the implicit connections to other modules of the grammar assumed in earlier work.

It is our hope that the confluence of this modern focus on formal explicitness and the long tradition of empirical richness will see work on argument structure and mapping theory enter a new heyday in LFG, and perhaps allow it to reach a level of maturity where it can start to address questions of an explanatory rather than simply descriptive nature.

Further reading

Here we give pointers to some important on topics not discussed or only briefly touched upon in the main body of the chapter.

[48] Although lexical rules may still used in other domains beyond argument alternations: see e.g. Bresnan, Asudeh, et al. (2016, 234, fn. 9).

Meta-theoretical questions

Argument alternations and argument structure played a central role in the development of lexical theories of syntax, like LFG. Early seminal works include Chomsky (1970), Mchombo (1978), Bresnan (1978), and Bresnan (1982), and Butt and King (2006 [1983]). Bresnan, Asudeh, et al. (2016, ch. 3) walk the reader through much of this argumentation.

From a more modern perspective, S. Müller and Wechsler (2014) review different approaches to argument structure, and argue in favour of the lexical approach normally assumed in LFG over what they call "phrasal" approaches common in Construction Grammar (e.g. Goldberg 1995).

Complex predicates

For more detailed discussion of the implications of complex predicates for argument structure and mapping theory, see the following, *inter alia*: T. Mohanan (1994, 1997), Butt (1995, 1997, 2014), Alsina (1996, 1997), Bodomo (1996, 1997), Ackerman and Webelhuth (1998), Wechsler (2003, 2008), Sudmuk (2005), Lowe (2016), and Ehsan and Butt (2020).

There has been extensive work on the development of computational grammars in XLE that can handle complex predicates, with a particular focus on Urdu: see Butt, King, and Maxwell (2003), Butt and King (2007), Butt, Bögel, et al. (2012), and Sulger (2013).

Another area of interest is the consequences of complex predicates for the syntax-semantics interface: on this, see Kaplan and Wedekind (1993), Dalrymple, Hinrichs, et al. (1993), Andrews and Manning (1999), Andrews (2007), Homola and Coler (2013), and Lowe (2015).

Argument structure and mapping theory in the noun phrase

As well as verbs, mapping theory has also been applied to eventive nouns (so-called ACTION NOMINAL CONSTRUCTIONS). Rappaport (1983) is an early account identifying different mapping principles for verbs and nouns.

Work within Classical LMT has examined such constructions in various languages: see Kelling (2003) on French, Markantonatou (1995) on Modern Greek, Falk (2001a) on Modern Hebrew, Laczkó (2000, 2003, 2004, 2010) on Hungarian, Saiki (1987) on Japanese, and Sulger (2013) on Urdu. See also Lowe (2017) for an alternative perspective, drawing on evidence from Sanskrit and other early Indo-Aryan languages.

Areas of debate include the types of arguments available to nominal predicates, and the consequences of any limitations for argument mapping: a prohibition on $[+o]$ arguments of nouns has been generally accepted (Rappaport, 1983; Laczkó, 2000, p. 211). There have been different perspectives on whether $[-r]$ arguments are available to nouns, with some work rejecting this possibility (Rappaport, 1983; Kelling, 2003), other authors allowing such arguments (Falk, 2001a; Laczkó, 2000) and others remaining ambivalent (Markantonatou, 1995).

Double object constructions

First proposed by Alsina and Mchombo (1993 – originally circulated as a manuscript in 1989), and further discussed in Bresnan and Moshi (1990) and Alsina and Mchombo

(1990), the ASYMMETRICAL OBJECT PARAMETER distinguishes those languages (like English) where the two objects in a double object construction behave differently (e.g. only one can be promoted via passive), from those (like Kichaga) where they do not (e.g. both can be promoted via passive or flagged via marking on the verb). This parameter has featured most prominently in discussions of Bantu applicative constructions: in addition to the papers cited above, see also Harford (1993), which focuses on Chisona, and Mchombo and Firmino (1999), a comparative study of Chichewa and Gitonga. Huang and Her (1998) consider ditransitives and the Asymmetrical Object Parameter with respect to Chinese, Joshi (1993) with respect to Marathi, Lødrup (1995) with respect to Norwegian, and Camilleri and Sadler (2012) with respect to Maltese. Kibort (2008) considers the syntax and mapping theory analysis of ditransitive constructions more generally.

Ergative-absolutive systems

There is scant work in mapping theory on ergative-absolutive languages, and we encourage further work in this area. Notable exceptions include Manning (1996), which argues among other things for the importance of a separate level of a-structure for analysing ergative languages, and Kumara Henadeerage (2002), which considers argument structure and argument alternations as part of a wider investigation of Colloquial Sinhala, an ergative language. Related work includes that of Arka (2008, 2014, 2019), which considers data from ergative languages in addressing questions about voice and the argument/adjunct distinction, and Wechsler and Arka (1998), which examines argument structure and split ergativity in Balinese from the perspective of HPSG.

Other topics of interest

Some predicates select "dummy" arguments, which are realised in the syntax but have no semantic content. How they participate in mapping theory is addressed by Bresnan and Zaenen (1990) and Zaenen and Engdahl (1994). Very often these pleonastic arguments surface to satisfy the Subject Condition – nevertheless, some languages, or specific constructions within languages, seem to violate this condition routinely: on such genuinely subjectless constructions, see Kibort (2006).

At the turn of the millennium there was interest in connecting LFG and Optimality Theory; this trend was felt in work on mapping theory as well. For some examples, see Morimoto (1999, 2000) and Asudeh (2001).

Mapping theory has also been investigated in relation to language acquisition: see Pienemann, Di Biase, and Kawaguchi (2005), Kawaguchi (2007), Kawaguchi (2009), Di Biase, Kawaguchi, and Yamaguchi (2015), Iwasaki and Oliver (2018), and Li (2021).

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