A Categorial-Modal Logical Architecture of Informativity

Dependency Grammar Logic & Information Structure

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> *Here is one more system of philosophy. If the reader*
> *is tempted to smile, I can assure him that I smile*
> *with him, and that my system [...] differs widely in*
> *spirit and pretensions from what usually goes by that*
> *name. [...] I am merely attempting to express for the*
> *reader the principles to which he appeals when he smiles.*
>
> - George Santayana, *Scepticism and Animal Faith* (1955)

ABSTRACT

The dissertation elaborates how a categorial-modal logical framework, Dependency Grammar Logic (DGL), can be used to provide a basic model of certain components underlying the Praguian conception of linguistic meaning. The components dealt with here are head/dependent-asymmetries, "semantic roles" or dependency relations, and information structure. We address the representation, realization, and interpretation of these components, paying particular attention to cross-linguistic modeling. We propose hypotheses that predict cross-linguistic commonalities and differences in realizing dependency relations and information structure, and explain how these predictions can be integrated into multilingual grammar fragments that model these phenomena.

Set within the Praguian tradition, the dissertation argues that each of the aforementioned components are necessary to explain sentential form and interpretation. Information structure is a means that the speaker employs to present some parts of the sentence's meaning as context-dependent, and others as context-affecting. It is therefore an inherent aspect of a sentential meaning.

Languages can realize information structure using various means, like variation in word order, tune, or morphological marking. The distinction of heads and dependents, rather than "phrases", offers a flexible notion of surface structure that is needed for the modeling of word order variation and tune, both typologically and formally.

Distinguishing dependency relations like **Actor**, **Patient**, or **Beneficiary** leads to a fine-grained description of sentential meaning. The dissertation argues that named dependency relations are necessary for explaining the realization of information structure and focus projection. Furthermore, they play a role in the interpretation of linguistic meaning. The dissertation explains how causal and temporal dependency relations can effectuate aspectual change, and how interpreting a word as a particular type of dependent can give rise to entailments that must be accommodated in the discourse context for the linguistic meaning to be coherent. Finally, distinguishing named dependency relations offers the means to model the resolution of phenomena such as exempt anaphora.

The dissertation consists of two parts. The first part describes the foundations of DGL. DGL produces and represents linguistic meaning by coupling a resource-

sensitive categorial proof theory to hybrid modal logic. A representation of a sentence's linguistic meaning is obtained in a compositional, monotonic way from the analysis of its surface form, as in standard categorial grammar. Chapter 2 introduces the basic concepts of hybrid logic, and shows how it can model ontological richness and contextual reference. Chapter 3 discusses linguistic meaning in more detail. It gives a hybrid logical formalization of the semantic import of dependency relations, and explains how dependency relations may thus specify the causal, temporal and spatial structure of a sentence's meaning. Chapter 4 presents the categorial calculus. It discusses head/dependent asymmetries, a cross-linguistic account of the realization of dependency relations in terms of morphological strategies, and the formalization of these concepts in DGL. The chapter explains how compositionality is achieved, and concludes with a proposal for how to create multilingual grammar fragments called grammar architectures.

The second part describes information structure. Chapter 5 discusses various theories of information structure that describe both the realization and the interpretation of information structure, and presents arguments for choosing the Praguian approach. The chapter concludes with a discussion of the representation of information structure in DGL at the level of linguistic meaning. Chapter 6 presents predictions about how information structure can be cross-linguistically realized through word order variation and tune. These predictions give rise to strategies characterizing a (typological) category of informativity, and Chapters 7 and 8 show how these strategies can be modeled in grammar architectures. Chapter 7 provides architectures modeling word order as a structural indication of informativity. Chapter 8 discusses an abstract model of tune, and explains how it can be smoothly integrated with the word order architectures to provide a model of how tune and word order can interact to realize information structure. Using these architectures, DGL can build a representation of a sentence's linguistic meaning with its information structure in a compositional, monotonic way. Chapter 9 explains how these representations are interpreted dynamically against a discourse model, which is illustrated on a basic model of anaphoric binding that also covers exempt anaphora.

ACKNOWLEDGEMENTS

Valet illatio ab esse ad posse.

The fact that my name appears on the title page as the sole author should not be taken too seriously, as I would never have been able to complete my project without the help of many others.

Many thanks are first of all due to my supervisors, Eva Hajičová and Petr Sgall. Through the years they have proven to be a great support. They have helped me to understand the Prague School, taught me linguistics, and despite distance or the enormous amount of material I managed to write they were always willing to read and provide detailed feedback. I hope that they find at least some of their ideas back in this work. In Prague, I would also like to thank Jarmila Panevová, Jarda Peregrin, and Niki Petkevič for many stimulating conversations.

Furthermore, I owe much gratitude to my mentors in categorial grammar, Dick Oehrle and Mark Steedman. They both have been a very important influence in the way DGL developed formally, and never tired of reading and helping to improve my work. Other people that were instrumental were Michael Moortgat, Glyn Morrill, Mark Hepple, Guy Barry, Mary McGee-Wood, Herman Hendriks, Esther Kraak and Dirk Heylen, for discussions on categorial grammar. Big thanks go to Richard Moot for his Grail system for categorial type logics, and the support he provided. Carlos Areces, Patrick Blackburn and Alexander Koller helped me a great deal with coming to grips with hybrid logic. Furthermore, it was very stimulating to be discussing mathematics and dependency grammar with Norbert Bröker and Sylvain Kahane, human sentence processing with Shravan Vasishth, functionalist linguistics with John Bateman and Elke Teich, and HPSG with Paul King and Valia Kordoni. Jason Baldridge, Gann Bierner, and Julia Hockenmaier proved great office mates during my time in Edinburgh – I hope we keep on working together! Finally, a big thanks go to all the people I met at

ESSLLI summer schools and at the Vilém Mathesius Lecture Series, for a great experience.

I would like to thank COMPULOG NET, the Association for Symbolic Logic, TELRI, IJCAII and TMR for travel grants over the years, Charles University and the Universität des Saarlandes for financing two work stays in Saarbrücken (Arbeitsprogram), the University of Birmingham and the Universität Tübingen for invited talks, and the University of Edinburgh (ICCS) for its hospitality during my time there.

And in the end, I am –for once– without words when it comes to thank my family, and especially Ivana. Thank you for sharing the Road with me, for being a home, for always supporting me.

Geert-Jan Kruijff
Edinburgh/Prague
March 2001

CONTENTS

CHAPTER 1

QUESTIONS ASKED AND THESES PROPOSED

> *But before I launch out into those immense depths*
> *of philosophy, which lie before me, I find myself*
> *inclined to stop a moment at my present station, and*
> *to ponder that voyage, which I have undertaken.*
> – David Hume, *A Treatise of Human Nature*

1.1 INTRODUCTION: QUESTIONS AND THESES

The central thesis of this dissertation is that we can build a categorial-modal logical framework (Dependency Grammar Logic, DGL) that provides a basic model of certain components of the Praguian conception of linguistic meaning. The components we deal with here are head/dependent-asymmetries, dependency relations and information structure, addressing their representation, realization, and interpretation. The dissertation shows (i) how DGL can build a representation of a sentence's linguistic meaning with its information structure in a compositional, monotonic way, and (ii) how we can subsequently interpret the sentential linguistic meaning dynamically in an information structure-sensitive discourse representation theory.

We focus in this dissertation primarily on information structure, which is a means that the speaker employs to present some parts of the sentence's meaning as context-dependent, and others as context-affecting. It is therefore an inherent aspect of a sentential meaning. Across languages we can observe different ways in which information structure can be realized. Depending on the type of language, information structure may be structurally indicated in the surface form of the sentence through word order, tune, or morphology. For example, in languages that have a relatively free word order, like Czech or Turkish, information structure is primarily realized through variation in word order. On the other hand, languages with a rigid word order, like English, mostly employ tune, punctuation, or (marked) syntactic constructions.

A language's use of for example word order or tune is, usually, not absolute. Instead, we find that languages make use of various kinds of structural indications of informativity, depending on how marked a sentence's information structure is in a given context. For example, although Czech predominantly employs word order to realize information structure, both (marked) tune and word order are used in constructions involving subjective ordering. Similar constructions in Japanese lead to the use of morphological marking, word order, and tune.

The fact that we not only find that different structural means are used to realize information structure *across* languages, but also *within* a single language in an *interactive* fashion, gives rise to several questions concerning the description of information structure and its realization that are at the heart of this dissertation.

Question. What would be a framework that is powerful enough to describe information structure (as an aspect of sentential meaning) and its realization using means like flexible word order, tune, and morphological marking?

The first question asks *where* we describe information structure and its realization. An answer to this question is essential, as it determines the formal outset from which we can approach the second question and the third question. People have approached information structure from various angles, anywhere between discourse pragmatics and surface syntax. In this dissertation, I consider information structure from the viewpoint of grammar, being the description of the relation between form and its underlying meaning.

Thesis 1. *Information structure can be integrated into a theory of grammar at the level representing the linguistically realized meaning of a sentence.*

With regard to "being powerful", any grammar framework we would consider should naturally enable us to describe phenomena involving flexible word order, tune, and morphological marking. This is an important formal requirement, which I return to in the next section. Question 1 also phrases a more linguistically oriented requirement that concerns the description of the structural indications of informativity (i.e. form).

Thesis 2. *The way information structure is realized through the possible* *interaction of word order, tune, and morphological marking, and can be captured by means of multidimensional linguistic signs and operations on such signs.*

In the end, a complete answer Question 1 would not necessarily constitute a *theory* of the relation between information structure and its possible realization. The issue is not just to be able to describe *that* information structure is realized by tune or word order, for example. If information structure is to be a universal aspect of sentential meaning, then a theory should be able to explain *why* a language may avail itself of particular structural indications of informativity, and *when* it would do so - from a cross-linguistic perspective.

Question. From a cross-linguistic viewpoint, how could we *predict* what structural indications of informativity a particular language may probably use?

Question. From a language-internal viewpoint, how could we describe not only *how* a language may use e.g. word order or tune, but also predict *when* a language would do so?

Questions 2 and 3 find their ultimate justification in the general consideration that information structure is a universal phenomenon. In this dissertation I try to formulate preliminary answers to these questions by having recourse to language typology. In keeping with the contemporary understanding of "typology", I try to establish cross-linguistic patterns that reveal how languages may share, or differ in, their ways of realizing information structure. These patterns can be derived from basic facts about a language's morphological system and its dominant word order patterns.

Thesis 3. *The typification of a language in terms of its morphology and dominant word order patterns determines how a language may realize information structure.*

Because I use a relatively small empirical basis, these patterns take the form of hypothetical implications rather than universal implications. The goal here is primarily to argue that it appears possible to identify such patterns, and that the corresponding implications can be used to guide decisions how to provide, for a given language, a grammar fragment that describes the principal ways in which that language realizes information structure.

Thesis 4. *Typological implications can be used to guide decisions about how to provide a grammar model of the way a language may realize information structure.*

The patterns elucidate how typologically similar languages share particular means in realizing information structure, or how they may differ. This idea of (dis)similarity can be systematically carried over to the domain of grammatical modeling. That is, if languages are similar in particular ways, then that commonality can be reflected in the models for these languages. As a first step, the models for these languages can be let to share the formal descriptions that model the behavior their respective languages have in common. But matters can arguably be taken further than mere reuse. With proper attention to the design of fragments and their interrelation, it is possible to create a single *architecture* in which the fragments live and where their applicability to model a particular language is determined by the typological hypotheses. Thus, rather than having specific grammar fragments for modeling some phenomena in each language separately, we obtain a hybrid set of grammar fragments. The entire set models the same phenomena, but is sensitive to the typological patterns when determining what rules (fragments) to apply for a particular language.

Thesis 5. *An architecture can be built that models how typologically varied languages may share or differ in aspects of how they realize information structure, based on patterns observed cross-linguistically.*

Finally, Thesis 6 completes the circle between Thesis 1 which concerns the representation of information structure at the level of linguistic meaning, and Thesis 5.

Thesis 6. *A compositional account can be given of the relation between the representation of information structure at the level of linguistic meaning, and its realization at the surface form.*

1.2 Approach

Nowadays, we have access to a plethora of grammar formalisms. The theses already indicate a certain disposition towards monostratal, compositional theories. These choices can be justified in a very brief way. A principle of compositionality allows for a perspicuous interface between linguistic meaning and its realization as a surface form. Contemporary monostratal approaches use multidimensional signs that not only represent various levels of linguistic information in a compact fashion, but also allow for these different types of information to interact. Both compositionality and interaction between different levels of linguistic information are often hard to obtain in more stratificational (transformational) approaches to grammar.

However, Thesis 1 explicitly states that the goal is to represent information structure. As said, information structure expresses the contextuality of a sentence's linguistic meaning. Consequently, a sentence's linguistic meaning need *not* necessarily have a determinable truth-value when considered in isolation. By its very nature, linguistic meaning only expresses the conditions under which the sentence could be true, since for example anaphoric resolution is not a linguistic but an extra-linguistic/"cognitive" mechanism – cf. (Sgall et al., 1986) and work by Rooth, Karttunen.

Clearly, this places a notion of linguistic meaning with information structure distinctly at odds with the more traditional notion of semantics that follows from the work of for example Carnap, Austin, and Montague. Instead, we need a "Post-MG" grammar formalism to deal with this, as for example (Hajičová et al., 1998) and (Peregrin, 1999) point out.

The grammar formalism I develop in this dissertation is called *Dependency Grammar Logic* or DGL for short. DGL combines the linguistic intuitions from a Praguian view on dependency grammar (Sgall et al., 1986) with the logical tradition of categorial grammar - categorial type logic, cf. (Moortgat, 1997). For its internal mechanisms, DGL uses the resource-sensitive proof theory of categorial type logic. These mechanisms operate on multidimensional signs in which a representation of a sentence's form, and the structure we can assign it, is compositionally related to a representation of the sentence's linguistic meaning. To formalize the latter, DGL does not use a typed predicate logic but employs hybrid logic, which is a sorted modal logic.

A fundamental characteristic is that DGL adopts a dependency-based view on grammar, following the Praguian tradition. Thus, a sentence's linguistic meaning is represented as a (tree-like) structure in which the meanings of dependents are related to the meanings of heads. Characteristic for the Praguian approach is, first of all, that these relations are named, indicating how exactly the meaning of a dependent contributes to that of the head it modifies. Secondly, for each dependent and each head its informativity is noted. Context-dependent or “given” items are marked as contextually bound (CB), “new” items are marked as contextually nonbound (NB). There are several reasons for taking a dependency-based perspective. First of all, dependency relations are needed to explain the *realization* of information structure in e.g. Tagalog (Kroeger, 1993), and the *systemic ordering* over dependency relations is fundamental to an explanation of focus projection (Sgall et al., 1986; Vallduví and Engdahl, 1996). Furthermore, dependency relations are needed for explaining the *interpretation* of information structure (e.g. exempt anaphora). Finally, a dependency-based framework gives *by definition* rise to head/dependent asymmetries and a flexible notion of surface structure. Both of these are necessary for explaining two important means for realizing information structure: word order variability and tune.

The advantages of using hybrid logic can be made clear at this point. Because we conceive of linguistic meaning as a relation structure, it is no more than natural to adopt a modal logic to formalize such structures. The propositional, sortal nature of hybrid logic adds to that by enabling a fine-grained model of lexical and linguistic meaning (e.g. abstract/concrete entities, temporal structure), and the possibility to explicitly model the contribution a dependent makes to the overall meaning (the semantic import of the dependency relation).

Thesis 7. *Dependency relations trigger entailments about aspects of the structure of a discourse context, and these entailments (their semantic import) can be modeled explicitly using hybrid logic.*

The importance of discerning the semantic import of a dependency relation is that, depending on the dependent's contextual boundness the entailment may either have to be presupposed (CB) or just accommodated (NB). Last, but not least, hybrid logic includes a reference mechanism (the @-operator) that lends itself naturally to modeling contextual reference. And, it enables a relatively easy way to handle (complex) information structure - overcoming the problems encountered in a typed approach like (Kruijff-Korbayová, 1998).

The dependency perspective DGL takes is also reflected in the way form is analyzed. The overall goal of such analysis is, of course, to discern heads, dependents, and their relations such that a representation of the sentence's linguistic meaning can be composed, in parallel. In DGL, analysis is a symbiosis of the dependency perspective and the categorial perspective, the former specifying vertical organization (head-dependent asymmetry) and the latter horizontal organization (linearization).

The impact of including a dependency perspective in what is technically a categorial type of analysis is twofold. Firstly, we can deal with surface structure in a way that is very flexible, much more flexible than one arising from the immediate constituency hypothesis adopted in traditional phrase-structure grammar. This flexibility is important to be able to give an adequate account of both word order and tune, the two foremost means to realize information structure. It goes without saying that it is akin to the idea of "flexible constituency" as we find it in for example (Steedman, 1996) or (Hendriks, 1993). But, the Praguian dependency perspective gives a slight twist to this picture - and this is the second point we would like to make. Not only do we structure sentential form into heads and dependents rather than phrases, thus obtaining mentioned flexibility - we also discern what type a dependent is, according to the dependency relation along which it modifies a head. In an important sense we thus shift our locus of attention from a pre-occupation with linearization to the interpretation of form, trying to establish how it reflects an underlying linguistic meaning. With that we do not lose any descriptive adequacy, but in fact gain some. For example, there exist coordination phenomena that can only be explained adequately when one distinguishes different types of dependency relations, cf. (Panevová, 1974).

Similarly, the (resource logical) categorial analysis we adopt to develop a Praguian dependency perspective makes an important contribution to the overall effort. It provides us with the means to give a detailed account of surface word order, morphology, and intonation. Because we employ multidimensional signs, the information from each linguistic levels can be used to constrain, or guide, operations on information at another level. First of all, DGL employs these means to explicate the relation between the role a dependent plays in the linguistic meaning (its dependency relation), and its realized form. The ideas underlying this explication date back to (Kuryłowicz, 1964) and (Sgall et al., 1986), but find in DGL a more formal statement. With this, and the fact that all the dependency relations employed are empirically motivated (Panevová, 1974), (Sgall et al., 1986), DGL arguably overcomes the criticism that one cannot specify the relation between "dependency relations", "argument roles" or "θ-roles" - as noted for example by (Dowty, 1989), (Davis, 1996). Furthermore, we already remarked earlier on that languages often use various means to indicate a sentence's information structure. Multidimensional signs, and the structure and feature management of categorial type logic, provide the adequate means to model this.

I have gathered data about 20 languages to provide a preliminary account of why a particular language use specific structural indications of informativity, and when it does so. From the patterns these individual languages display I formulate hypotheses that imply the use of word order or tune to realize information structure. These hypotheses take the form of implications, like those in (Greenberg, 1966) or (Hawkins, 1983). These hypotheses are then tied to a model of variability in word order, and tune. The model takes the form of a network of structural rules, reflecting the idea of a system as for example in (Halliday, 1985).

1.3 OVERVIEW

The dissertation is divided into three parts.

In **Part I: Foundations of Dependency Grammar Logic**, the goal is to provide the formalism in which I can later formulate an account of information structure and its realization.

In **Chapter 2, Hybrid logics to represent meaning**, I begin by discussing hybrid logic. The chapter introduces the basic concepts behind hybrid logic, like nominals and propositions as different sorts, logical modalities, and the @-operator. To illustrate hybrid logic, I discuss various applications of hybrid logic - as a logic of attribute-value matrices, as a logic of temporal structure and temporal reference, or as a logic of knowledge representations. Thereafter, I explain how hybrid logic can be used as a logic to model linguistic meaning as well as a discourse context. As a result, the relation between a sentence's linguistic meaning and its interpretation can be described directly. The two are not conflated though, precisely because of the possibility (in hybrid logic) to differentiate between the statement *that* something refers (@) and the resolution of that reference (binding of nominals to states). This corresponds to the fundamental Praguian intuitions behind linguistic meaning, but makes the approach different from for example both (Kamp and Reyle, 1993) and (Van Eijck and Kamp, 1997).

In **Chapter 3, From word meaning to linguistic meaning**, I focus in more detail on three important components in the formation of linguistic meaning: predicate-valency structures, aspectual categories, and dependency relations and their semantic import. Predicate-valency structures specify the meaning of a head and by what kinds of dependency relations the head has to be modified. With predicate-valency structures that can be realized by e.g. verbs also the action-type or aspectual category should be specifiable, as it reflects a causal and temporal structure (Steedman, 2000b) that causative or temporal dependency relations may specify further and which is projected to the discourse context (thus influencing coherence). To that end, I first develop a hybrid logic that combines a hybrid temporal logic like (Blackburn, 1994) with a (linguistic) theory of aspectual categories and aspectual change (Steedman, 2000b). This logic then gets integrated into the logic of linguistic meaning. Thereafter, I discuss the dependency relations of (Sgall et al., 1986) in detail, providing examples of their use, and giving (preliminary) definitions of their semantic import in terms of a hybrid logic. These explications elaborate an initial classification of dependency relations as given in (Sgall et al., 1986). Even more importantly, they make it clear how linguistic meaning can project entailments, not only by virtue of its information structure (to be discussed later) but also following from dependency relations and aspectual categories. These entailments play an important role in the interpretation of linguistic meaning in a discourse context, as these entailments need to be "accommodated" for the linguistic meaning to be coherent. Finally, the chapter shows how various dependency relations may effectuate aspectual change, thus influencing what the aspectual category of the clause is.

In **Chapter 4, Form and function in Dependency Grammar Logic** I show how the hybrid logic of linguistic meaning developed in the previous chapters can be tied to the resource-sensitive proof theory of categorial type logic - in other words, to define DGL as a framework of grammar. To that end I first of all define the formal apparatus, in the shape of a headed categorial calculus in which the analysis of form leads to the compositional formation of linguistic meaning. Like any other categorial approach, the inference in DGL's calculus is driven by categories that are reflections of the underlying meaning they realize. Traditionally the logical tradition derives categories from Ty_2-formulas, but DGL no longer does this - it uses a dependency-based, hybrid-logical specification of meaning. The main issue that thus arises, is how to let a category reflect a predicate-valency structure and its dependency relations. But this is no new issue. Key observations have been made by Mathesius, Jakobson, and -later- Kuryłowicz regarding the relation between morphological form and dependency relations. I argue how these observations can be fruitfully used to provide a procedure of category-formation that is based on linguistic motivations - a possibility arising from the Praguian view on dependency grammar. I end the chapter with a proposal for an approach to cross-linguistic modeling in categorial grammar, introducing the concept of a grammar architecture.

To recapitulate, Part I provides a dependency-based grammar formalism that finds its linguistic motivation in the Prague School of Linguistics, and which can construct logical descriptions of linguistic meaning in a compositional and monotonic way using a categorial analysis of a sentence's form. By virtue of a detailed description of aspectual categories and dependency relations, the formulation of a sentence's linguistic meaning in DGL not only elucidates which dependents modify what heads, but also what causal and temporal entailments are triggered. On the categorial side, DGL develops out a headed calculus, morphological strategies, and the notion of a grammar architecture. Taken altogether, this provides us with a basis for Part II.

In **Part II: The category of informativity**, the overall aim is to provide a preliminary account of how we can explain the realization of information structure across typologically different languages, and how such an explanation can be integrated into a grammar framework.

The second part starts with **Chapter 5, Theories of information structure**. In this chapter, I discuss various theories of information structure that have found their way into formal grammar. Based on reflections on these theories, I motivate why I opt for the Praguian approach and how it is (conceptually) closely related to Steedman's theory of information structure. The chapter ends with definitions spelling out how information structure is represented in DGL (contextual boundness, topic-focus articulation), and a few preliminary remarks on the dynamic interpretation of linguistic meaning and its information structure, to be defined later in Chapter 9.

In **Chapter 6, The category of informativity**, I discuss a basic typological characterization of when languages use variability in word order or tune to realize information structure, thus trying to characterize contextual boundness as a typological *category of informativity*. The characterization is based on empirical data from a variety of typologically different languages, and a new typology of variability in word order. First I formulate a set of typological hypotheses that predict whether a language has rigid, mixed, or free word order, integrating (Steele, 1978) with Skalička's language typology (Skalička and Sgall, 1994; Sgall, 1995b). Subsequently, I argue for a set of hypotheses that predict where to expect the canonical focus position, and when languages use word order, tune or a combination thereof to realize information structure. These sets of hypotheses form the typological basis for the grammar architectures to be presented in the next two chapters.

In **Chapter 7, A formal model of word order as structural indication of informativity**, I elaborate various grammar architectures that model variability in word order and how that variability can be used as a structural indication of informativity. The architectures are illustrated on a large number of examples from a variety of languages. The approach I take to modeling variability is motivated in the beginning of the chapter, where I present a discussion of various categorial accounts that have been provided to model variation in word order. Here, I opt for viewing adjacency as a *parameter*. This enables us to consider information structure as a primary factor (parameter) determining word order. Information structure and word order as a structural indication of informativity are related through the notion of systemic ordering, which indicates here whether dependents are realized in canonical order or not. This provides a useful abstraction over a concrete prosodic/syntactic structure, and I show in the next chapter how it enables us to smoothly integrate tune and word order as structural indication of informativity into a single model.

Besides word order languages usually also use tune to realize information structure – sometimes even predominantly so, like in the case of English. In **Chapter 8, A formal model of tune as structural indication of informativity**, I begin with a discussion of Steedman's model of English tune developed in Combinatory Categorial Grammar. I then present a more abstract model of tune that can be instantiated to cover different languages, and that overcomes a few problems I note for Steedman's proposal. The chapter ends with a discussion of how we can include the model of tune in the word order architectures of Chapter 7, to provide a model of the *interaction* between tune and word order in realizing information structure.

Finally, in **Chapter 9, DGL, topic/focus, and discourse**, I address the interpretion of sentence's linguistic meaning. After (Peregrin, 1995; Kruijff-Korbayová, 1998) I define the interpretation of linguistic meaning dynamically, guided by the linguistic meaning's information structure. I elaborate the discourse model from Chapter 2 to provide a reformulation of Kruijff-Korbayová's TF-DRT (Kruijff-Korbayová, 1998). On the resulting proposal I illustrate how binding across clauses can be modeled using hybrid logic's jump-operator.

To recapitulate, I provide in this part a preliminary, typological account of how word order variability and tune can realize information structure. This account is coupled to comprehensive models of word order tune as structural indication of informativity. The grammar architectures can be used in DGL to create a representation of a sentence's linguistic meaning, including information structure, as the result of an analysis of that sentence's form. At the end of this part, I show how such a representation can be further interpreted on a discourse model that is sensitive to information structure (Kruijff-Korbayová, 1998).

In **Part III: Final remarks** I compare my approach and its results to other approaches, and conclude with final remarks and topics for further research.

PART I

FOUNDATIONS OF DEPENDENCY GRAMMAR LOGIC

"... Kit Fine has compared the position of the linguist or artificial intelligencer who turns to logic for this purpose to that of a man in need of trousers who goes to a tailor, only to be told that tailors made jackets, and that in fact only jackets are necessary, for it is easy to show that jackets are topologically equivalent to trousers. Such is the authority of logicians that otherwise decorous persons have found themselves in the position of trying to use jackets as trousers. When they have complained that jackets don't seem to work very well as trousers, the response has often been impatient. Sometimes the users have been led to give up on logic entirely and to go off and invent their own knowledge representations. This is a shame, because in the end one's trousers are best made by tailors, and logicians are the best people to make knowledge representations."

– Mark Steedman (2000b)

"There's only two things I want to say: (a) Take things seriously, and (b) Let them talk to each other."

– Patrick Blackburn and Maarten de Rijke (1997)

CHAPTER 2

HYBRID LOGICS TO REPRESENT MEANING

Hybrid logic is a modal logic that provides us with means to logically capture two essential aspects of meaning in a clean and compact way, namely ontological richness and the possibility to refer. In this chapter I present the basic concepts of hybrid logic: sorts, modalities, and the @-operator. These concepts are illustrated on a few sample applications, after which I explain how we can use hybrid logic to represent linguistic meaning as well as a discourse context. One of the results of this chapter is a modest proposal for a DRT-like theory of discourse interpretation, modeled in hybrid logic.

> *Il n'existe pas de sciences appliquées,*
> *mais seulement des applications de la science.*
> – Louis Pasteur

2.1 HYBRID LOGICS

Hybrid logics are modal logics that enable one to *sort* atomic symbols, and they provide an internal means to *refer* to propositions. Sorting is a strategy that has been proposed by various authors to create *ontologically rich* representations of meaning (cf. (Vendler, 1967), (Dowty, 1979), (Van Benthem, 1996)). The take on sorting in hybrid logics differs from many-sorted type logics like Ty_2 (with sorted types e, t; Gamut (1991)) or Ty_3 (s, e, t) in that we create an ontology that stays at the level of *propositions* (after Prior).

A direct consequence of employing a propositional ontology is that hybrid logics lead to more perspicuous representations than are usually offered by first-order logic (FOL) or even higher-order logic (HOL). But there is more to hybrid logics than that. Even though we know that hybrid logics can have the same expressive power as FOL, they in general enjoy more interesting formal characteristics like decidability and relatively low computational complexity (Areces et al., 1999; Areces et al., forthcoming).

Thus, hybrid logics take us back into the realm of the computable, and with their (often) clean and compact representation they offer an attractive *applied logic.* Below I present various applications of hybrid logic, all of which sooner or later become integrated into the story unfolded in this dissertation - e.g. attribute-value matrices, temporal logic. Before that, let me define the most basic hybrid logic, $\mathcal{H}(@)$.[1]

Definition 1 (Basic hybrid multimodal language $\mathcal{H}(@)$). *Given a set of propositional symbols PROP=*$\{p,q,r,...\}$*, and a set of modality labels MOD=*$\{\pi, \pi', \pi'', ...\}$*. Let NOM be a nonempty set of* nominals*, disjoint from PROP and MOD. Typically, elements of NOM are written as i, j, k. We define the basic hybrid multimodal language* $\mathcal{H}(@)$ *(over PROP, MOD, and NOM) to be the set of well-formed formulas such that:*

$$WFF\ \phi := i \mid p \mid \neg\varphi \mid \varphi \wedge \psi \mid \varphi \vee \psi \mid \varphi \rightarrow \psi \mid \langle\pi\rangle\varphi \mid [\pi]\varphi \mid @_i\varphi.$$

For any nominal i, we call the symbol sequence $@_i$ *a satisfaction operator.* ⊛

Remark 1 (Hybrid logic extends modal logic). Traditionally, modal logics provide a framework for working with relational structures, consisting of states and transitions. However, the perspective modal logic offers is strictly *internal* and *local.* The way a model theory for modal logic works is that we can only inspect the current state s at which we evaluate a formula φ, and the states accessible from s. Modal logics do not enable us to say something like "this happens there" or "this state has property ϕ" as we lack the means to refer to states within a formula itself (i.e. within the object language).

Areces characterized this situation as there being an *asymmetry* at the heart of modal logic. Although states are crucial to the (Kripke-based) model theory for modal logic, nothing in the syntax of modal logic enables us to get a grip on *states as such.* This is a genuine weakness - it makes modal logic an inadequate representation formalism for most practical purposes, and the inability to refer to states (at which particular propositions hold) raises difficulties in developing a proof theory for modal logic.[2]

Hybrid logic solves these problems by adding the means to refer to states.

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[1] Most of the definitions in this section come from Blackburn's (2000b) unless stated otherwise.

[2] For the relation to work on proof theory and modal logic by for example Fitting, see (Blackburn, 2000a).

Technically, what we do is add *nominals* as a new sort, next to different sorts of propositions. Each nominal names a unique state. To get to that state, we add a new operator that enables us to "jump" to the state named by the nominal. The key feature now is that *all* this information is represented in the formulas that a hybrid logic works with.

The satisfaction operator mentioned in Definition 1 is a simple way of exploiting this key feature - i.e. the fact that we can now explicitly name states by using nominals, and that nominals are formulas. A formula "$@_i\varphi$" means "go to the (unique!) state named by i, and check whether φ is true at that state." Or, to put it slightly differently, $@_i\varphi$ is a way of asserting *in the object language* that φ is satisfied at some state (namely, the one named by i). ⊛

Definition 2 below gives the model theory for $\mathcal{H}(@)$. As with any sorted approach, to get the sorting strategy really working we need to ensure the semantics reflects the plan thus laid out.

Definition 2 (Hybrid models, satisfaction, and validity). *A hybrid model* $\mathfrak{M}$ *is a triple* $(\mathcal{W}, \{R_\pi \mid \pi \in \mathcal{MD}\}, V)$*, where* $(\mathcal{W}, \{R_\pi \mid \pi \in \mathcal{MD}\})$ *is a frame consisting of a set of states* $\mathcal{W}$ *and a set of relations* R_π *for each modal* π *in* $\mathcal{MD}$*, and* V *a* hybrid valuation. *A hybrid valuation is a function with domain* $\mathcal{P} \cup \mathcal{N}$ *and range* $\wp(\mathcal{W})$ *such that for all nominals i, V(i) is a singleton subset of* $\mathcal{W}$*. We call the unique state in V(i) the denotation of i. We interpret hybrid multimodal languages on hybrid models as follows:*

$$\begin{array}{lll}
\mathfrak{M}, w \models p & \textit{iff} & w \in V(p),\ \textit{where}\ p \in \mathcal{P} \\
\mathfrak{M}, w \models \neg\phi & \textit{iff} & \mathfrak{M}, w \not\models \phi \\
\mathfrak{M}, w \models \phi\ \wedge\ \psi & \textit{iff} & \mathfrak{M}, w \models \phi\ \textit{and}\ \mathfrak{M}, w \models \psi \\
\mathfrak{M}, w \models \phi\ \vee\ \psi & \textit{iff} & \mathfrak{M}, w \models \phi\ \textit{or}\ \mathfrak{M}, w \models \psi \\
\mathfrak{M}, w \models \phi\ \rightarrow\ \psi & \textit{iff} & \mathfrak{M}, w \not\models \phi\ \textit{or}\ \mathfrak{M}, w \models \psi \\
\mathfrak{M}, w \models \langle\pi\rangle\phi & \textit{iff} & \exists w'(wR_\pi w'\ \&\ \mathfrak{M}, w' \models \phi) \\
\mathfrak{M}, w \models [\pi]\phi & \textit{iff} & \forall w'(wR_\pi w' \Rightarrow \mathfrak{M}, w' \models \phi) \\
\mathfrak{M}, w \models i & \textit{iff} & w \in V(i),\ \textit{where}\ i \in \mathcal{N} \\
\mathfrak{M}, w \models @_i\phi & \textit{iff} & \mathfrak{M}, w' \models \phi, \textit{where w' is the denotation of i.}
\end{array}$$

If ϕ *is satisfied at all states in all hybrid models based on a frame* $\mathfrak{F}$*, then* *we say that ϕ is valid on $\mathfrak{F}$, which we can write as $\mathfrak{F} \models \phi$. If ϕ is valid on all frames, then we say that it is valid and write $\models \phi$.* ⊛

Remark 2 (Hybrid logics: *still* modal (besides being *hybrid*)). Of course, by adding nominals to modal logics, we do not *lose* anything - hybrid logics are still modal. For example, the satisfaction operator is a normal modal operator, since for any nominal i we have that $@_i(\phi \to \psi) \to (@_i\phi \to @_i\psi)$ is valid. Moreover, if ϕ is valid, then obviously so is $@_i\phi$.

What is more, hybrid logics are not only modal, they are also *hybrid* (Blackburn, 2000b)(p.348). As we pointed out, besides the ordinary propositions we have nominas, which enable us to refer *in the object language of the logic* to states in the model. Because nominals are formulas, we can also construct the formula $@_ij$. This formula states the equivalence of i and j, i.e. both i and j refer (uniquely) to one and the same state. Similarly, we can express statements about relations between states: $@_i\langle\pi\rangle j$ conveys that the state named by j is an R_π-successor of the state named by i. Such a genuinely hybrid formula is called a *pure formula* - see Definition 3 below. ⊛

Definition 3 (Pure formulas). *A well-formed formula φ (according to Definition 1) is called* pure *if it does not contain any propositional variables.* ⊛

Pure formulas play an important role in characterizing properties of modal operators, describing their behavior in the frames they are interpreted on. Blackburn (2000b)(p.353) gives an example using the Priorian $\langle \mathsf{P} \rangle$ and $\langle \mathsf{F} \rangle$. Here, I use pure formulas to characterize relations in a discourse structure, and familiar notions like (contextual) accessibility. But this has to wait until Section 2.2 - first, let me give some examples of hybrid logics in action.

Example (Feature logic). It has often been noted that attribute-value matrices can be considered as notational variants of a formula in a modal logic that distinguishes different modal operators. For example, consider the following attribute-value matrix and its corresponding modal formula:

(1) a.
$$\begin{bmatrix} \textsc{agreement} & \begin{bmatrix} \textsc{person} & \textit{1st} \\ \textsc{number} & \textit{plural} \end{bmatrix} \\ \textsc{tense} & \textit{present} \end{bmatrix}$$

b. $\langle\textsc{agreement}\rangle(\langle\textsc{person}\rangle 1st\ \wedge\ \langle\textsc{number}\rangle plural)$
$\wedge\ \langle\textsc{tense}\rangle present$

However, it has turned out to be useful to relate nodes in an attribute-value matrix by using labels like $\boxed{1}$ (re-entrancy):

(2)
$$\begin{bmatrix} \textsc{agreement}\ \boxed{1} & \begin{bmatrix} \textsc{person} & \textit{1st} \\ \textsc{number} & \textit{plural} \end{bmatrix} \\ \textsc{comp} & \begin{bmatrix} \textsc{subj} & \boxed{1} \end{bmatrix} \end{bmatrix}$$

Ordinary modal logic would not be able to capture this attribute-value matrix, because of its use of a re-entrancy. A hybrid setting, on the other hand, enables us to model it in a straightforward manner, due to the availability of nominals:

(3) $\langle\textsc{agreement}\rangle(i\ \wedge\ \langle\textsc{person}\rangle 1st\ \wedge\ \langle\textsc{number}\rangle plural)$
$\wedge\ \langle\textsc{comp}\rangle\langle\textsc{subj}\rangle i$

As Blackburn observes in (1993; 2000b), attribute-value matrices are essentially a two-dimensional notation for (multi-)modal logics with nominals - i.e. hybrid logics. ⊛

Example (Temporal logic). In the 1950's and 1960's, Prior essentially rediscovered tense logic, and described its initimate connection with modal logic (see Øhrstrøm & Hasle's (1993)). Nowadays most people are familiar with Prior's "past" $\langle\mathsf{P}\rangle$ and "future" $\langle\mathsf{F}\rangle$ operators (1967). With these operators we can create (propositional) statements of the form as in (4a,b).

(4) a. $\langle\mathsf{P}\rangle\varphi$ - "It was the case that φ."
b. $\langle\mathsf{F}\rangle\varphi$ - "It will be the case that φ."

Let us consider a concrete example.

(5) a. Elijah accidentally broke the blue vase.
b. $\langle\mathsf{P}\rangle(\mathsf{Elijah\text{-}accidentally\text{-}break\text{-}the\text{-}blue\text{-}vase})$

The point here is that the representation of (5a), given in (5b), fails to capture an important intuition about the (English) past. As Blackburn points out in (1990; 2000b; to appear), if we have a sentence as in (5a), then the corresponding modal formula in (b) does not reflect that the event didn't just happen some time in the past, but at a particular, contextually determined point in time even though the identity of the point may not be known to the speaker/hearer.

Here, the nominals we have at our disposition in hybrid logic can come to the rescue. Consider again the example modal formula in (5b). Consider the truth conditions of the hybrid logic sentence in (6), a variant of the modal formula (5b).

(6) $\langle \mathsf{P} \rangle (i \wedge \mathsf{Elijah\text{-}accidentally\text{-}broke\text{-}the\text{-}blue\text{-}vase})$

This is true exactly if there is a state i in the past at which "Elijah breaks the vase" holds. The formula thus represents *exactly* our intuitions about events in the past.⊛

Example (Description logic). In description logics, we can define languages that enable us to talk about concepts and their interrelations - what is called the TBox (or terminology box) in KL-ONE style knowledge representations. For example, consider the concept of being a PhD-student, which we could (loosely) describe as being a student who is supervised by a professor. Using the language $\mathcal{ALC}$ described by Schmidt-Schauss and Smolka in (1991) we can define the concept by the expression

$$\mathit{student} \sqcap \exists \textsc{supervisor}.\mathit{professor}$$

We have that *student* and *professor* are concept names, SUPERVISOR is a role name, and $\sqcap$ is a boolean operator (intersection). In fact, as Schild pointed out in (1991), any $\mathcal{ALC}$ corresponds to a modal formula - for example, in our case we only need to replace $\sqcap$ by $\wedge$ and $\exists R$ by $\langle R \rangle$:

$$\mathit{student} \wedge \langle \textsc{supervisor} \rangle \mathit{professor}$$

Besides a TBox we also have an ABox, short for "assertion box". The ABox specifies how the concepts and properties defined in the TBox apply to individuals. For example, to assert that GJ is a student we include *GJ:student* in the ABox, and to say that GJ is writing a hefty dissertation we state *(GJ, hefty-dissertation)*:WRITE.

The TBox and the ABox are separate levels in the knowledge representation. Some description logics do, however, enable us to make assertions about individuals at the level of the TBox as well. This is then done by using the one-of operator, $\mathcal{O}$: $\mathcal{O}$(Gann,Jason,...,GJ) selects one of the individuals Gann, Jason,..., GJ.

The resulting description logic, $\mathcal{ALCO}$, is a notational variant of the @-free fragment of $\mathcal{H}(@)$ ($\mathcal{H}(@)\backslash @$). Every nominal i in this fragment corresponds to an expression $\mathcal{O}(i)$, whereas a statement $\mathcal{O}(i, j, ..)$ in $\mathcal{ALCO}$ corresponds to $i \vee j \vee ...$ in $\mathcal{H}(@)\backslash @$.

We are not restricted to $\mathcal{H}(@)\backslash @$ though. @ has a natural interpretation in description logics: the ABox statement $i : \varphi$ corresponds to $@_i\varphi$, and (i, j):R is translated into $\mathcal{H}(@)$ as $@_i\langle \mathrm{R}\rangle j$. The translation of $\mathcal{ALCO}$ into $\mathcal{H}(@)$ *does* give a new turn to the story, though. In $\mathcal{ALCO}$, the ABox still constitutes a level different from the TBox - whereas the $\mathcal{H}(@)$ translations of ABox statements are part of the object language.

Areces (2000) describes further possible extensions between description logics and hybrid logics. The interesting bit here of course is that, even though we -effectively- create an extension to $\mathcal{ALCO}$ when using $\mathcal{H}(@)$, we remain in the realm of the computable - see the work by Areces, Blackburn and Marx (1999; forthcoming) and by Blackburn and Tzakova (1998) for more results. ⊛

To round off this brief exposition of hybrid logic, I present Blackburn's tableaux system for reasoning in hybrid logic. Thanks to the presence of nominals and the satisfaction operator @, it is possible to equip hybrid logic with a proof theory in a relatively straightforward manner. As Blackburn puts it, hybrid logic not only internalizes the labelling mechanism as proposed by Gabbay (1996) - it also internalizes the labelling *discipline* because nominals are first-class citizens in the language. It is this possibility of being able to express satisfaction directly in the object language that the tableaux system exploits to define "valid reasoning".

Definition 4 (An unsigned tableaux system for hybrid reasoning). *Following Blackburn's (2000a; 2000b), we represent deduction in a hybrid logic as an unsigned tableaux system. The rules are divided into two groups. The first group defines (internalizes) the satisfaction relation:*

$$\frac{@_s\neg\varphi}{\neg @_s\varphi}\ \neg \qquad\qquad \frac{\neg @_s\neg\varphi}{@_s\varphi}\ \neg\neg$$

$$\frac{@_s(\varphi\ \wedge\ \psi)}{\begin{array}{c}@_s\varphi\\ @_s\psi\end{array}}\ \wedge \qquad \frac{@_s\neg(\varphi\ \wedge\psi)}{\neg @_s\varphi \mid \neg @_s\psi}\ \neg\wedge$$

$$\frac{@_s @_t\varphi}{@_t\varphi}\ @ \qquad\qquad \frac{\neg @_s @_t\varphi}{\neg @_t\varphi}\ \neg @$$

$$\frac{@_s\langle\pi\rangle\varphi}{\begin{array}{c}@_s\langle\pi\rangle a\\ @_a\varphi\end{array}}\ \langle\pi\rangle \qquad\qquad \frac{\neg @_s\langle\pi\rangle\varphi \quad @_s\langle\pi\rangle t}{\neg @_t\varphi}\ \neg\langle\pi\rangle$$

$$\frac{@_s[\pi]\varphi \quad @_s\langle\pi\rangle t}{@_t\varphi}\ [\pi] \qquad\qquad \frac{\neg @_s[\pi]\varphi}{\begin{array}{c}@_s\langle\pi\rangle a\\ \neg @_a\varphi\end{array}}\ \neg[\pi]$$

Here, s and t are metavariables over nominals, and a is a metavariable over new *nominals (i.e. nominals not yet used in the tableaux construction so far). Note that $\vee, \rightarrow$ can be defined using $\neg, \wedge$ in the usual way. (See also Example 2.1 on page 23 below.)*

The second group of rules defines additional (necessary) mechanisms for nominals and @. This group of rules is essentially a classical rewriting system:

$$\frac{[s\ on\ branch]}{@_s s}\ Ref \quad \frac{@_t s}{@_s t}\ Sym \quad \frac{@_s t \quad @_t\varphi}{@_s\varphi}\ Nom \quad \frac{@_s\langle\pi\rangle t \quad @_t t'}{@s\langle\pi\rangle t'}\ Bridge$$

As with any standard tableaux system, we prove formulas by systematically trying to falsify them (i.e. constructing a countermodel). We call a tableaux closed *if every branch contains a formula ϕ and its negation $\neg\phi$. A formula ϕ is proved if the tableaux constructing its proof is closed. On the other hand, a formula ϕ' is not valid (not provable) if it is not possible to close the tableaux. In that case, the near-atomic satisfaction elements on the open branch specify a countermodel.* $\circledast$

Example (A sample derivation in hybrid logic). Let us consider a few sample derivations (Blackburn, 2000b). Every time we try to prove a formula φ, we take a nominal i that does *not* appear in φ, prefix φ by $\neg @_i$, and start the tableaux from there. In other words, we try to prove the statement $\neg @_i \varphi$ - “There is an arbitrary state i where φ does not hold.” If the tableaux closes, then it is not possible to construct the countermodel (validating $\neg @_i \varphi$), and hence φ is proven. Otherwise, as we already said in Definition 4 above, the near-atomic satisfaction elements on the open branch specify a countermodel.

1	$\neg @_i(\langle\pi\rangle(p \vee q) \rightarrow \langle\pi\rangle p \vee \langle\pi\rangle q)$	
2	$@_i \langle\pi\rangle(p \vee q)$	1,$\neg \rightarrow$
2’	$\neg @_i(\langle\pi\rangle p \vee \langle\pi\rangle q)$	1,$\neg \rightarrow$
3	$\neg @_i \langle\pi\rangle p$	2’, $\neg\vee$
3’	$\neg @_i \langle\pi\rangle q$	2’, $\neg\vee$
4	$@_i \langle\pi\rangle j$	2, $\langle\pi\rangle$
4’	$@_j (p \vee q)$	2, $\langle\pi\rangle$
5	$\neg @_j p$	3,4, $\neg\langle\pi\rangle$
6	$\neg @_j q$	3’,4, $\neg\langle\pi\rangle$
7	$@_j p \quad \mid \quad @_j q$	4’, $\vee$
	$\clubsuit\ 5,7\ \clubsuit \qquad \clubsuit\ 6,7\ \clubsuit$	

The derivation above proves a standard multimodal validity, $\langle\pi\rangle(p \vee q) \rightarrow \langle\pi\rangle p \vee \langle\pi\rangle q$. $\circledast$

Example (A simple application in description logic). For our second example we turn once more to description logics. To keep matters simple, let us take the following TBox and ABox:

$$\text{TBox} = \{\ \textsf{Man-of-War} \sqsubseteq \textsc{locomotion}.\textsf{Sailing}\ \}$$
$$\text{ABox} = \{\ \textsf{seven-provinces: Man-of-War}\ \}$$

We already saw in Example 2.1 on page 21 how to translate such statements into hybrid logic (Areces, 2000):

$$@_{\textsf{Man-of-War}} \langle \textsc{locomotion} \rangle \textsf{Sailing} \qquad (=\text{TBox})$$
$$@_{\textsf{seven-provinces}}\ \textsf{Man-of-War} \qquad (=\text{ABox})$$

A tableaux proof is now just like a query to our knowledge base. For example, we might want to know whether the “Seven Provinces”[3] navigates by sail. If the “Seven Provinces” does sail, we should be able to prove that $@_{\textsf{seven-provinces}} \langle \textsc{locomotion} \rangle\ \textsf{Sail}$.

---

[3] The “Zeven Provinciën” (or “Seven Provinces”, since the Dutch Republic in the 17th century consisted of seven rather independant lands) was a Man-of War originally built in 1664-1665 for the Admiralty of the Meuse in Rotterdam, by Master Shipbuilder Salomon Jansz van den Tempel.

1	$\neg @_i (@_{\mathsf{seven\text{-}provinces}} \langle \textsc{locomotion} \rangle \mathsf{Sail})$	
2	$\neg @_{\mathsf{seven\text{-}provinces}} \langle \textsc{locomotion} \rangle \mathsf{Sail}$	$1, \neg @$
3	$@_{\mathsf{Man\text{-}of\text{-}War}} \langle \textsc{locomotion} \rangle \mathsf{Sailing}$	*Axiom*
4	$@_{\mathsf{seven\text{-}provinces}}\ \mathsf{Man\text{-}of\text{-}War}$	*Axiom*
5	$@_{\mathsf{seven\text{-}provinces}} \langle \textsc{locomotion} \rangle \mathsf{Sail}$	$3, 4, Nom$

♣ $2, 5$ ♣

Finally, it can be proven that the hybrid tableaux are sound and complete.

Theorem 1 (Soundness and completeness of hybrid tableaux). *φ is tableau provable iff φ is valid.*

Proof. *Cf. (Blackburn, 2000a), §5,6. Soundness can be established from satisfaction statements (over a systematic construction of tableaux, §5). Blackburn provides an accompanying completeness proof for unimodal hybrid logics using a Hintikka set argument (§6) which extends straightforwardly to the multimodal case considered here.* ⊛

2.2 A SIMPLE THEORY OF DISCOURSE REPRESENTATION

In this section I develop a simple theory of discourse representation, based on Kamp's Discourse Representation Theory (Kamp and Reyle, 1993; Van Eijck and Kamp, 1997). The defining characteristic of the proposal is that it is phrased entirely in terms of hybrid logic. The point of doing so is simple: I want to use a single (logical) formalism for describing a sentence's linguistic meaning (as an outcome of the grammar) and for describing the interpretation of a sentence at the level of the discourse context. This results in the possibility to describe the *relation* between linguistic meaning and discourse interpretation *directly*.[4]

---

[4] Thus, it becomes possible to give a more perspicuous account of how linguistic meaning "projects" various kinds of entailments (presuppositions, allegations, etc.) to the level of discourse, and how -vise versa- the discourse context can influence the determination of a sentence's (possible) linguistic meaning. There is no longer any need for a translation from one formalism to another, like in classical Discourse Representation Theory (Kamp and Reyle, 1993). Translation-based approaches to linking grammar and discourse theory are prone (more easily) to display a phenomenon that is known in the NLG community as "the generation gap", (Meteer, 1991). Van Eijck and Kamp discuss in (1997) a fragment in which lexical entries in the grammar are assigned DRSs (i.e. suitably typed expressions). The DRS for a sentence is obtained by building it compositionally, i.e. in parallel to the sentence's syntactic structure. A criticism that can be levelled against (Van Eijck and Kamp, 1997) is though that Van Eijck and Kamp assume indexation, thus effectively bypassing reference resolution.

2.2.1 Representing discourse

DRT represents a discourse context using *discourse representation structures* (DRSs for short). Each DRS consists of a universe and a set of conditions (7). The universe is a set of discourse referents - by which we mean eventualities or entities that occur in the discourse. Conditions predicate properties holding for discourse referents. Here I give just a loose characterization of DRT - what interests me most here are the intuitions behind DRT, not their formalization as given in (Kamp and Reyle, 1993) or (Van Eijck and Kamp, 1997).

(7)

Universe
Conditions

Now, consider the discourse in (8).

(8) a. Christopher reads a book.
b. He likes it.

For each eventuality (here, referred to by a content verb) and each entity, we introduce a discourse referent. The individual DRSs for (8a,b) are given below in (9).

(9) a.

e x y
read(e,x,y) *Christopher(x)* *book(y)*

b.

e' v w
like(e',v,w) *v=?* *w=?*

Note how in the DRS for (8b) we have identity equations with question-marks ? - pronouns like "he" and "it" introduce discourse referents that need to be *bound* to their proper antecedents. Because the individual DRSs have not yet been integrated, we are not able to resolve pronominal reference.

(10)

e e' x y v w	
read(e,x,y)	*like(e',v,w)*
Christopher(x)	*v=x*
book(y)	*w=y*

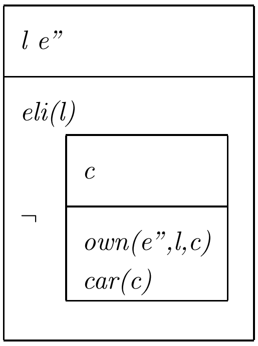
The integrated DRS is given in (10). DRT resolves pronominal reference by finding a suitable, *accessible* antecedent. The accessibility of a discourse referent depends on what universe it belongs to. If it belongs to the universe of the main DRS then it is always available. On the other hand, if the discourse referent belongs to a subordinate (embedded) DRS, its accessibility is restricted.

A quick example of an embedded DRS is the case of (simple) negation. Take a sentence as in (11a), and the incoherent follow-up in (11b).

(11) a. Elijah does not own a car.
b. # He parked it in front of the house.

In DRT we represent the negated information ("not owning a car") in a DRS that is embedded under a negation sign (12).

(12)



Because l is defined at the level of the main DRS, we are allowed to reuse it in the embedded DRS. However, the discourse referents e'', c are *not* accessible outside their DRS. This explains the incoherence of (11b): We can succesfully bind the discourse referent for "he" to l, but their is no accessible, eligible antecedent for "it".

How could we represent discourse in hybrid logic, following similar ideas as we explored above? The answer is exceedingly simple - *consider discourse referents as nominals, and conditions as propositions holding at the states named by these nominals.*

Blackburn already used nominals to model discourse referents in (1990; 1994), when discussing temporal intersentential anaphora. The focus there was on nominals modeling eventualities, showing that a hybrid tense logic could model Partee's approach as advocated in (1984). Here I take Blackburn's idea simply one step further, following out the sorting strategy to its logical conclusion, and consider every kind of discourse referent a nominal.

Given the fact that we essentially have a propositional setting, we need a way to *relate* an eventuality nominal with entity nominals. Following Kruijff-Korbayová's TF-DRT (1998), I explicitly represent argument roles or *dependency relations.* In the next chapter I explain dependency relations in more detail - for the moment it suffices to regard them to signify *how* the meaning of a dependent contributes to the linguistic meaning of the overall sentence. In FGD Sgall et al distinguish close to forty different dependency relations; in the example below, I only consider familiar roles like **Actor**, **Patient** or **Locative**.

Modalities of course provide an excellent means to represent relations. Given a set of dependency relations $\Delta = \{\delta_1, ...\delta_n\}$, we can define modals $\langle\delta_i\rangle, [\delta_i]$. Example (13) below illustrates how this works out in practice. (13a) gives the sentence, and (13b) indicates the different arguments (using a bracketing in the fashion of (Petkevič, 1995)). (13c) then gives the representation in hybrid logic.

(13) a. Elijah owns a comic book.

b. [Elijah $]_{Actor}$ owns [a comic book $]_{Patient}$.

c. $(i \wedge own \wedge \langle \textsc{Actor} \rangle (e \wedge Elijah) \wedge \langle \textsc{Patient} \rangle (b \wedge comic - book))$

Using pure formulas like (14), it is straightforward to define a particular dependency relation δ as an inner participant, in the sense of FGD. [5]

(14) $@_i \langle\delta\rangle j \wedge @_i \langle\delta\rangle k \ \rightarrow \ @_j k$

Because attribute-value matrices are a notational ("multidimensional") variant of the linear formulas of $\mathcal{H}(@)$, it is easy to see how (13c) could be written as an attribute-value matrix (with the modality made explicit):[6]

(15)
$$\begin{bmatrix} \boxed{i} & \wedge\ own \\ \langle \textsc{Actor} \rangle & \begin{bmatrix} \boxed{e} & \wedge\ Elijah \end{bmatrix} \\ \langle \textsc{Patient} \rangle & \begin{bmatrix} \boxed{b} & \wedge\ comics\text{-}book \end{bmatrix} \end{bmatrix}$$

---

[5] A inner participant is a dependency relation by which a head can be modified no more than once, cf. (Sgall et al., 1986).

[6] Not representing any specific grammatical information, attribute-value matrices like the above are a tuned-down version of the more complex structures proposed for FGD by Petkevič in (1993).

But let us not diverge. At this point, I should consider the question of how to *integrate* representations of the linguistic meaning of individual sentences into a larger representation of the discourse context.

2.2.2 Composition and accessibility

Blackburn (1994) suggests a rather simple way of creating a representation of the discourse: conjoin ($\wedge$) the individual representations. Then, depending on the tense of each sentence (or rather, the Aktionsart of its linguistic meaning), we set the reference time (Reichenbach's R) by either keeping the reference time of the previous sentence (using the same nominal) or shifting it (introducing a new nominal).[7]

Blackburn illustrates this idea in (1994)(§4) on the discourse given in (16). The logical representation of (16) is given in (17): As said, every nominal picks out a reference time. To indicate that the reference time of i' is in the past of j', we state that $j' \wedge \langle \mathsf{P} \rangle i'$.

(16) a. John got up,
b. went to the window,
c. and raised the blind.
d. It was light out.
e. He pulled the blind down,
f. and went back to bed.
g. He was not ready to face the day.
h. He was too depressed.

(17) a. $\langle \mathsf{P} \rangle (i \wedge John\ get - up)$
b. $\langle \mathsf{P} \rangle (j \wedge \langle \mathsf{P} \rangle i \wedge John\ go\ to\ the\ window)$
c. $\langle \mathsf{P} \rangle (k \wedge \langle \mathsf{P} \rangle j \wedge John\ raise\ the\ blind)$
d. $\langle \mathsf{P} \rangle (k \wedge it\ be\ light\ out)$
e. $\langle \mathsf{P} \rangle (i_1 \wedge \langle \mathsf{P} \rangle k \wedge John\ pull - down\ the\ blind)$
f. $\langle \mathsf{P} \rangle (j_1 \wedge \langle \mathsf{P} \rangle i_1 \wedge John\ go - back\ to\ the\ bed)$
g. $\langle \mathsf{P} \rangle (j_1 \wedge John\ be\ not\ ready\ to\ face\ the\ day)$
h. $\langle \mathsf{P} \rangle (j_1 \wedge John\ be\ too\ depressed)$

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[7] Note that, even though $\wedge$ is in principle symmetric, the relations between the reference times are not symmetric because of $\langle \mathsf{P} \rangle$.

Instead of Blackburn's idea of using conjunction ($\wedge$) as merge-operator, I propose to merge the representation of a sentence's linguistic meaning with the discourse context as follows. First of all, I assume a merge operator $\oplus$. For the moment, it suffices to understand $\oplus$ as Blackburn's conjunction - later on, I will give $\oplus$ a more dynamic interpretation (in the spirit of Kuschert's (1996) and Kruijff-Korbayová's (1998)) after I have discussed information structure in more detail. Secondly, a representation is merged with the context not just by $\oplus$, but by $\oplus$ and a specific *discourse relation* - like in Asher's SDRT (1993). Again, for the moment it suffices to consider a rather generic discourse relation, denoted here as $\langle\Re\rangle$.

Finally, I need to spell out how to define *(contextual) accessibility.* Using nominals we can do this in a *flexible* manner: namely, by means of pure formulas. Technically, we thus link the notion of (contextual) accessibility to frame definability (Blackburn, 2000b)(p.353). Linguistically, we have now at hand a way that is powerful, intuitivily perspicuous, and flexible enough to give a very fine-grained definition of (contextual) accessibility: With pure formulas, we can define how accessibility can be conditionalized on the (modal) relations involved.

Definition 5 (Accessibility of $\langle XS\rangle$ wrt. $\langle\Re\rangle$). *We define (contextual) accessibility as a relation* ⟨XS⟩*, for which the following rules hold w.r.t.* $\Re$. Δ *is the set of dependency relations.*

(Main-ev) $@_j\langle XS\rangle i \;\rightarrow\; @_i\langle\Re\rangle j$

(Main-en) $@_j\langle XS\rangle k \;\wedge\; @_i\langle\Re\rangle j \rightarrow\; @_i\langle\delta\rangle k$*, for any* $\delta \in \Delta$.

⊛

Remark 3 (Accessibility on the main universe). The rules given in Definition 5 define the accessibility of discourse referents at what would correspond to the level of the *main* DRS. The rule (Main-ev) states that when an eventuality i is accessible to another eventuality j, i is (directly) related by $\langle\Re\rangle$ to j. (Main-en) states that the entities providing the arguments for i are also accessible to j, provided i and j are related through $\langle\Re\rangle$. ⊛

To be able to illustrate in an interesting way how the proposal works in this rather minimal setting, let me first explain what to do with pronominal reference. I propose to model the meaning of a pronoun in the abstract way as given in (18).

Definition 6 (Abstract model of pronominal reference).

(18) $(k \wedge @_k \langle XS \rangle (k' \wedge \bigwedge conditions))$

⊛

Remark 4 (Pronominal reference means the possibility to jump). The abstract specification of pronominal reference, given in the Definition above, is really quite simple. It states, in a concise way, that we need to be able to jump back to a contextually accessible nominal that names a state k' at which one or more conditions ($\bigwedge conditions$) hold. To illustrate how this works out in practice, I give some examples in (19) below.

(19) a. "he": $(k \wedge @_k \langle XS \rangle (k' \wedge \mathbf{male}))$
b. "it": $(k \wedge @_k \langle XS \rangle (k' \wedge \mathbf{object}))$

It seems worthwhile pointing out that the specification here is more fine-grained than "$v = ?$". The examples in (19) explicitly require a discourse referent to have particular semantic features (in the spirit of (Dowty, 1979; Sgall et al., 1996)).

Then, to round off this brief discussion of pronominal reference, how do we actually *ensure* that a pronoun indeed is related to an appropriate, accessible antecedent? Again, the answer is fairly straightforward. We can construct a tableaux, with the context action as "axioms", and try to prove the negation of, for example, $(k \wedge @_k \langle XS \rangle (k' \wedge \mathbf{male}))$. If there is no suitable referent, then the tableaux does not close. ⊛

Subsequently, the discourse model of a small discourse (20) then takes the form as in (21), using the same "shift-reference" mechanism as Blackburn described in (1994).

(20) a. Elijah bought a cowboy-hat.
b. It cost a fortune.
c. He is wearing it today.

(21)
$$\begin{aligned}
&\langle \mathsf{P} \rangle (i \wedge \mathbf{buy} \\
&\quad \wedge \langle \textsc{Actor} \rangle (e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \\
&\quad \wedge \langle \textsc{Patient} \rangle (h \wedge \mathbf{cowboy-hat} \wedge \mathbf{object})) \\
&\oplus \langle \Re \rangle \ \langle \mathsf{P} \rangle (i \wedge \mathbf{cost} \\
&\qquad\qquad \wedge \langle \textsc{Actor} \rangle (h' \wedge @_{h'} \langle XS \rangle (h \wedge \mathbf{cowboy-hat} \wedge \mathbf{object}))
\end{aligned}$$

$$
\begin{aligned}
&\qquad\qquad \wedge \langle \textsc{Patient} \rangle (f \wedge \textbf{fortune}) \\
&\oplus \langle \Re \rangle\ (j \wedge \langle \mathsf{P} \rangle i \wedge \textbf{wear} \\
&\qquad\qquad \wedge \langle \textsc{Actor} \rangle (e' \wedge @_{e'} \langle XS \rangle (e \wedge \textbf{Elijah} \wedge \textbf{male})) \\
&\qquad\qquad \wedge \langle \textsc{Patient} \rangle (h'' \wedge @_{h''} \langle XS \rangle (h \wedge \textbf{cowboy} - \textbf{hat} \wedge \textbf{object})) \\
&\qquad\qquad \wedge \langle \textsc{Time:When} \rangle (@_j \mathit{today}))
\end{aligned}
$$

Remark 5 (Calendar terms; representation). A few remarks are in place regarding the representation in (21). Firstly, there is the *today* in the representation of the last sentence, to which the eventuality nominal j is linked (actually, equated). The *today* is an example of what we can do when we have a richer sorting - we can create different sorts of nominals, and Blackburn employs this strategy in (1990; 1994) to create a hybrid tense logic of calendar terms. The use of *today* is a reflection of that logic here. In the next chapter, I go deeper into tense logic, and how it can be integrated into DGL and ℧D.

⊛

SUMMARY

In this chapter I presented the basic concepts of hybrid logic, and illustrated them on a few examples. I also explained how the basic hybrid logic $\mathcal{H}(@)$ can be used to provide a representation of linguistic meaning (without information structure, for the moment). Because from the Praguian viewpoint linguistic meaning is a relational structure, hybrid logic provides a natural setting to give a logical account of such structures. In this chapter, I restricted the discussion mostly to representational issues. I discussed how to represent dependency relations as modal relations $\langle \cdot \rangle$ and discourse referents as nominals, and how to specify contextual reference at the level of linguistic meaning by making use of the @-operator. Besides discussing linguistic meaning, I also made a beginning with a proposal for how to use hybrid logic for providing a DRT-like theory of discourse. One advantage of doing so is that inference could easily be integrated into such a theory.

In subsequent chapters, I elaborate on the ideas presented here. In Chapter 3 I look in more detail at the representation of linguistic meaning. I make extensive use of hybrid logic's sorting strategy to provide a logic of aspectual categories and aspectual change, and to give logical descriptions of the semantic import of dependency relations. In Chapter 4 I address the issue of compositionality of linguistic meaning in the context of DGL, looking at how a representation of a sentence's linguistic meaning can be built in parallel to an analysis of its surface form.

Throughout the second part of the dissertation, I deal with the representation of information structure in linguistic meaning (e.g. see Chapter 5). At the end of the dissertation, in Chapter 9, I return to the proposal for a discourse theory formulated in hybrid logic.

Chapter 3

From word meaning to linguistic meaning

The aim of this chapter is to develop a logical account of three concepts that play an important role in the composition and specification of a sentence's linguistic meaning: predicate-valency structures, dependency relations, and aspectual categories. Predicate-valency frames specify the meaning of a head, and by what dependency relations it has to be modified. A dependency relation determines how the meaning of a dependent contributes to the overall (linguistic) meaning of the head it modifies. For example, causative and temporal dependency relations project entailments that may help determine a content verb's aspectual category (i.e. its causal and temporal structure). Such entailments may also need to be accommodated in the discourse context for the sentence's linguistic meaning to be coherent. The main results of this chapter are a logic of aspectual change and aspectual categories (after (Steedman, 2000b)), and a logical specification of basic aspects of the meaning of most dependency relations discerned in (Sgall et al., 1986).

3.1 Introduction

The aim of the current chapter is to make a beginning with explaining how the meanings of individual words which occur in a sentence compose into a conceivable linguistic meaning of that sentence. Underlying this aim are two assumptions. First of all, we assume that the purpose of a grammar is to describe the relation between surface forms of sentences to their conceivable linguistically realized meanings (i.e., linguistic meanings). Thus, grammar is not identical to syntax pure - well-formedness is only a waypoint in the effort to establish a sentence's underlying meaning.[1] Secondly, we assume that the behavior of a verb is to a large extent determined by its meaning,

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[1] Sharper contrasts can be drawn here between -at least- the Praguian viewpoint and other grammar frameworks. Whenever a sentence is well-formed, FGD considers there to be a corresponding linguistic meaning; ill-formed sentences do not express a linguistic meaning. The crucial point here is that even for sentences like "Colorless green ideas sleep furiously" we obtain a linguistic meaning, even though on most discourse models this meaning is probably nonsensical, cf. (Sgall et al., 1986) p.108ff. Thus, we make a distinction between the *absurdity* of meaning, and the *absence* of linguistic meaning.

particularly with respect to the expression and interpretation of its arguments[2] - cf. for example Panevová (1974; 1975) and Sgall *et al.* (1986) for the Praguian approach, but also Levin (1993) on lexical semantics of verbs, and much of contemporary work on categorial grammar (Moortgat, 1988; Steedman, 1996; Morrill, 1997). It is not difficult to see that the two points above taken together precipitate a close relation between a word's subcategorization ('surface syntax') and its (lexical) meaning, thus rendering surface structure (Chomsy's S-structures) superfluous and putting forward the representation of a sentence's linguistic meaning as the *only* proper (level of) representation.

For this reason I start with having a closer look at how we can specify a sentence's linguistic meaning. Following the intuitions behind Sgall *et al.*'s Functional Generative Description (FGD, cf. (Sgall et al., 1986)), linguistic meaning is conceived of here as a relational structure in which dependents modify heads along named dependency relations, and where each node in such a structure has an indication of its informativity (contextual boundness). Furthermore, following a perspective that goes back to at least Vendler (1967) and Dowty (1979), a specification of the sentence's aspectual category is added. The aspectual category reflects the causal and temporal structure that a sentence's linguistic meaning projects (Steedman, 2000b), determined by the main content verb and -possibly- causative and temporal dependents. Thus, a linguistic meaning's aspectual category and information structure are two important factors bearing upon its coherence with respect to a discourse context.

In this chapter I make extensive use of hybrid logic's sorting strategy and @-operator to give a logical account of aspectual change and aspectual categories (after (Steedman, 2000b)), and a logical specification of basic aspects of the meaning of the dependency relations discerned in (Sgall et al., 1986). Both show how not only information structure may trigger entailments that need to be accommodated in a discourse context, but that also a linguistic meaning's aspectual category and dependency relations may do so - for example, about causal and temporal structure. In §3.2 I discuss predicate-valency structures in more detail, and in §3.3 I develop a logic of aspectual categories and aspectual change on the basis of the model by

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[2] In fact, this relation between meaning and syntactic behavior is assumed to hold for *any* word that takes arguments.

Moens & Steedman, cf. (Steedman, 2000b). Finally, in §3.4 I present a preliminary account of the semantic import of dependency relations, and exemplify their use in various languages.[3]

3.2 PREDICATE-VALENCY STRUCTURES

A notion of valency is at the heart of most approaches to dependency grammar, and -on one interpretation or another- it specifies how the meaning of a word can be conceived of as a *function* taking the meanings of other words as *arguments*.

The idea of valency is used in dependency grammar to elucidate how a word acts as a function, requiring arguments (or "modifiers") for completion. As such, the valency of words can be likened to the original use of the term in chemistry, where it defines the bonding requirements of different elements.[4] Within dependency grammar, the notion of valency was introduced by Tesnière (1959).

3.2.1 PREDICATE-VALENCY STRUCTURES

How does a valency frame define the meaning of a word? One might think that a valency frame of a word is like a predicate, say **read**, and that predicate's arguments (the valency frame proper):

(22) $\mathbf{read}(x, y, z)$, or with the familiar λ's: $\lambda x \lambda y . \lambda z \mathbf{read}(x, y, z)$

This gives rise to an interpretation of a predicate and its arguments whereby the *order* in which the arguments appear (and are bound by the λ's) is essentially constitutive of their meaning. Thus, the first argument could be taken to hold what corresponds to the 'reader', whereas the second argument would then correspond to what is being read. This type of characterization is of course familiar from mathematical logic, and certainly gained prominence in formal semantics with the advent of Montague Grammar.

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[3] The account is 'preliminary' in that it is an attempt at providing between formal grammar, formal semantics, and (formal) lexical semantics, without claiming to be a complete description of all the possible semantic imports that each dependency relation may be understood to have.

[4] From a historical perspective, it might be interesting to note that Peirce, who had a Harvard degree in chemistry, used the concept of valency in his theory of relational algebra - and the application thereof to analyzing natural language sentences. See for example (Peirce, 1992), dating back to 1898. Note that the notion of valency was only introduced into chemistry in the second half of the 19th century.

However, this is not how we should understand a valency frame. In a valency frame, the meaning of an argument is not derived from its position in the predicate. Rather, we explicitly name the argument, and consider that name to be indicative of how that argument should be interpreted - how the argument's meaning contributes to the overall meaning. That 'name' characterizing the kind of argument comes from a small set of roles that is assumed to be cross-linguistically justifiable. For example, assume that we have two argument names, $\rho_{\mathit{1}}, \rho_{\mathit{2}}$, then we could represent a valency frame in either of the following ways:

(23) $\{(\mathit{predicate}\ \mathbf{read}), (\rho_{\mathit{1}}\ x), (\rho_{\mathit{2}}\ y)\}$

(24) $\lambda x \lambda y.\mathbf{read}(\rho_{\mathit{1}} : x, \rho_{\mathit{2}} : y)$

The valency frame in (23) is an example modelled after (Dowty, 1989). The example in (24) looks like the one in (22), though it is important to note that for assigning a meaning to the arguments we are no longer dependent on the order in which they are filled in.

Contemporary dependency grammarians differ though on the exact nature of the argument types we should use to specify valency frames: Should a valency frame specify a word's (syntactic) subcategorization, or its (semantic) argument structure? The former interpretation is adhered to in Hudson's Word Grammar (1984) or Maxwell's Unification Dependency Grammar (1995), among others. On the other hand, theories like Sgall *et al.*'s FGD (1986), Mel'čuk's Meaning-Text Model (1988) or Bröker's model-theoretic dependency grammar (1997) all consider valency frames to be of a more semantic nature, contributing to the specification of a word's meaning. With that, their notion of valency frame closely corresponds to, for example, the ideas behind θ-frames as used in Government & Binding(cf. (Haegeman, 1991)), and Fillmore's case frame's (1968).

Obviously, the conception of a valency frame as specifying a word's semantic argument structure, i.e. leading up to a definition of its *meaning*, brings about at least the following two issues:

1. How does a word's valency frame give rise to a subcategorization specifying the word's proper syntactic use?
2. How can dependency relations be characterized such that their import on contextual interpretation becomes clear (and predictable)?

The first question relates to problems raised by, for example, Dowty, Wechsler, and Davis against theories based on thematic roles (cf. Davis' (1996)) - particularly, the apparently problematic nature of such theories' explanation of linking thematic roles to subcategorization ("linking theory"). After explaining the syntactic apparatus of DGL in the next chapter, I will return to this question and argue how it can be satisfactorily answered in the context of DGL, following ideas advanced in e.g. Kuryłowicz (1964), Panevová (1974), and Sgall *et al.* (1986). The second question will be addressed in this chapter.

3.2.2 ARGUMENT COMBINATORICS

Normally, given a predicate and its argument positions, we consider it to be the case that each argument position should be filled for the predicate to be saturated, and that each argument position is filled by exactly one object. This picture also arises from semantic theories based on thematic roles. Davis (1996) (Ch.2) discusses a set of characteristics that holds for the early theories of thematic roles proposed by Fillmore, Gruber, and the thematic relations hypothesis developed by Gruber and later by Jackendoff. Although Davis points out that few would maintain all characteristics today, it is instructive to consider them:

(25) a. There is a small set of thematic roles.
  b. Thematic roles are atomic - there is no role that subsumes another.
  c. Each argument position in an argument structure is assigned exactly one thematic role.
  d. Thematic roles are uniquely assigned within an argument structure.
  e. Thematic roles are non-relational - the presence of one role does not imply the presence of another role in an argument structure.

Dowty proposes a smaller set of characteristics in (1989) (pp.78-79):

(26) a. (*Completeness*) Every argument position in an argument structure is assigned a thematic role.
  b. (*Distinctness*) Every argument position of every argument structure is distinguished from every other argument position in the

same argument structure by the thematic roles they are assigned.

i. (Variant 1) No two argument positions of the same argument structure are assigned the same thematic role, and every argument position is assigned only one thematic role.

ii. (Variant 2) No two argument positions of the same argument structure are assigned the same thematic role.

iii. (Variant 3) No two argument positions of the same verb are assigned exactly the same set of thematic roles.

Dowty and Davis discuss several problems that may be noted for theories based on thematic roles (and see also the lengthy discussion in Chapter 2 of (Sgall et al., 1986)). For the larger part, the problems they note are of a semantic-pragmatic nature.[5] As Hajičová and Sgall note in (Hajičová et al., 1998), though, such considerations have their proper place in contextual interpretation, not in establishing a sentence's linguistic meaning.[6]

Rather, our interest here is that the characteristics in (25) and (26) make clear that a theory might assume a combinatorics of arguments that is more involved than is ordinarily assumed in logic.

For FGD, an elaborate proposal for characterizing the combinatorics of arguments was advanced by Panevová in (1974). This proposal was adopted in (Sgall et al., 1986) and (Petkevič, 1987; Petkevič, 1995). To allow for an adequate description of how a predicate and its argument relate, Panevová suggests to employ criteria along *two* dimensions:

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[5] For example, as Oehrle (p.c.) notes, it can be doubted whether *thematic roles* are always atomic: Physical agency ("The storm destroyed our trees") is different from intentional agency ("John cut himself with the razor."). Similarly, it is not clear whether thematic roles are indeed non-relational. For example, it seems difficult to have an instrumental role without something undergoing the change.

[6] For example, both Davis and Dowty note the apparent problem with verbs denoting commercial transactions, like *buy*. As Jackendoff noted in the early 1970's, the buyer and the seller could both be considered to be "Agent" and "Source" (on Jackendoff's theory), since both make a transaction by handing something over and receiving something in turn. This observation, though interesting, is not a problem applicable to the kind of dependency grammar considered here. The 'fact' that there is a buyer and a seller in a commercial transaction, and that both are giving and getting objects, is an inference involving "world knowledge" and should therefore be relegated to contextual interpretation. It does not appear to have any bearing on determing the well-formedness of a sentence, nor on establishing its linguistic meaning. Similarly, Oehrle's comments regarding agency are not directly applicable to dependency grammar, as in both cases we consider the dependency relation to be an **Actor**. The difference is made elsewhere, namely outside the grammar.

(27) a. *Occurrence*: Whether a predicate can have only one argument of a given type, or several arguments of one and the same type.

b. *Obligatoriness*: Whether, for a given predicate, an argument position must be filled or may be left open.

Clearly, (27b) specifies whether an argument position is optional or obligatory. (27a) is best described by example: A verb can have only one argument that is specified as its **Actor**, but it can have more than one argument specifying when the eventuality (referred to by the verb) takes place (**Time:When**):

(28) [Last Wednesday $]_{T:When}$ [Christopher $]_{Actor}$ came home [in the evening $]_{T:When}$. (Panevová, 1994)(p.228)

Panevová calls **Actor** an *inner participant*, whereas **Time:When** is an example of a *free modifier*.

In contradistinction to various other theories that may bear resemblence to the approach we consider here (e.g. the semantic theories based on thematic roles, as discussed above), Panevová develops clear linguistic criteria for determining whether an argument (or dependency relation) is an inner participant or a free modifier, whether it is optional or obligatory, and in what sense we should understand such obligatoriness. Behind all these criteria is the idea that any distinction that we make should be linguistically relevant, and connected to surface-syntactic facts.[7]

To determine whether a particular dependency relation should be considered as an inner participant or a free modifier, Panevová proposes the following, fairly straightforward test ((1974), p.11):

(29) a. Can the given type of dependency relation modify every verb?

b. Can a verb be modified more than once by the given type of dependency relation?

A dependency relation is classified as an inner participant if it answers both questions in the negative.[8] To be classified as a free modifier, the

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[7] This places FGD clearly apart from for example Fillmore's theory, in which at least at a certain stage 'cases' were distinguished using a "subjective or impressionistic classification" (1974), p.29; see also the discussion in (Sgall et al., 1986), §2.11. The viewpoint that every distinction should be connected to observable (distinct) syntactic behavior also holds in a fundamental way for FGD' set of dependency relations, discussed below.

[8] Panevová actually points out that for the **Actor** the first question is answered positively (p.11). However, when we include impersonal verbs like *rain, snow*, etc. then it is

second question necessarily has to be answered positively. However, due to great variation in the semantics of adverbials (most of which are considered to be free modifiers), it is not necessarily the case that the first question is answered positively ((1974), p.12).[9]

Whether an argument is obligatory or optional (in a predicate-valency structure, i.e. at the level of linguistic meaning) can be determined by means of a *dialogue test.*[10] Intuitively, we can describe the dialogue test as follows. Assume we have two people participating in a dialogue, Elijah and Christopher. At one point in the dialogue, Elijah utters a sentence having a particular main verb. If, thereupon, Christopher asks a question pertaining to one of the verbal predicate's arguments, and that argument is an obligatory argument (though Elijah might have used ellipsis), then Elijah must be able to answer Christopher's question for the dialogue to continue naturally. If the (elided) argument is obligatory, Elijah cannot answer with "I don't know" - whereas he can if the argument is only optional.

For example, consider the following sample dialogue:

(30) a. (Elijah) "The Simpsons arrived."
b. (Christopher) "Where?"

After (30b), Elijah cannot utter "I don't know" since doing so would have a disturbing effect on the natural flow of the dialogue. In other words, the meaning of *arrive* includes a destination as an obligatory argument - when you say that someone arrived, you are expected to know *where to* that person arrived. At the same time, if Christopher would have asked "Where from?" then Elijah could have perfectly well answered that question by "I don't know where they had been" since knowledge thereof is not implied by

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clearly not the case that every verb has an **Actor** since mentioned verbs do not have one. This observation is made later on in (Sgall et al., 1986), cf. p.127.

[9] Regarding ellipsis, Sgall *et al.* (1986)(p.109) remark that "if a unit of the meaning of a sentence is deleted by an optional surface rule, on uttering the sentence, the speaker assumes that the hearer can easily recover the deleted item; if this condition were not met, the speaker would not have chosen the reduced surface variant."

[10] The dialogue test differs from the question test. The latter was briefly sketched by Sgall and Hajičová in (1970) as a means to characterize informativity of elements that make up a sentence's information structure. Particularly, as described in (Sgall et al., 1986), "the question test has a certain usefulness not only if we want to draw the boundary between topic and focus (or, between the [contextually bound] and [contextually nonbound] elements of the nucleus of a [tectogrammatical representation]), but also for assigning degrees of [communicative dynamism]" (p.211).

the meaning of the verb. That type of argument (**Direction:From Where**) is not obligatory for *arrive*.

Thus, to quote Panevová:

> "If A uses a sentence S and B asks him a *wh*-question concerning the participant P, A's answer might be "I don't know" (without disturbing the dialogue) if and only if the participant P is not semantically obligatory in S. (If S contains an embedding, it must be specified which verb is expanded by P in the question, and the answer must not, of course, switch to another verb.)" (1974), p.18

To sum up, let us have a brief look then at how FGD's characterization contrasts with the characteristics of thematic role-based theories, as noted by Davis and Dowty:

- To begin with, FGD shares the idea of there being a small, fixed set of dependency relations.

- Furthermore, it is also assumed that each argument position (and each argument) is assigned a single dependency relation (cf. also Petkevič's discussion in §3.1.1, (in prep)).

- However, unlike Dowty's *Distinctness* characteristic and Davis' (d) (which still holds for Government & Binding), FGD does allow for a predicate to be expanded by several arguments that are of the same type of dependency relation - namely, if that type of dependency relation is a free modifier.

- Another difference concerns obligatoriness: whereas it is implicit in Davis' and Dowty's characterizations that all arguments are obligatory, this is not the case in FGD.

As Panevová points out, the approach taken in FGD permits one to avoid extreme approaches, that arise either by restricting the analysis of verbal arguments to surface structure only, or by confusing linguistic structure and cognitive relations (in that every action always takes place at some time, at some place, in some manner, etc.).

3.2.3 PREDICATE-VALENCY STRUCTURES AND HYBRID LOGIC

In the previous chapter I already briefly illustrated how predicate-valency structures could be represented in hybrid logic - see for example 13 on page 27. Let me briefly repeat what was said there.

Modalities provide an excellent means to represent relations. Given a set of dependency relations $\Delta = \{\delta_1, ...\delta_n\}$, we can define modals $\langle\delta_i\rangle$ that model these relations, cf. also (Blackburn and Tzakova, 1998). Furthermore, I already briefly pointed out that the distinction between inner participants and free modifiers can be modeled using pure formulas. (31) expresses that δ is an inner participant. Formally, it does so by imposing the constraint that whenever j and k are both related to i by δ, then j and k refer to the same state. Intuitively, this means that a head, identified by i, can only be modified by a single δ-dependent: j and k refer to the same dependent.

(31) $@_i\langle\delta\rangle j \wedge @_i\langle\delta\rangle k \rightarrow @_j k$

Thus, FGD's classification of **Actor**, **Addressee**, **Effect**, **Origin**, and **Patient** as inner participants can be specified axiomatically in our logic, (32).

(32) a. $@_i\langle\textsc{Actor}\rangle j \wedge @_i\langle\textsc{Actor}\rangle k \rightarrow @_j k$
b. $@_i\langle\textsc{Addressee}\rangle j \wedge @_i\langle\textsc{Addressee}\rangle k \rightarrow @_j k$
c. $@_i\langle\textsc{Effect}\rangle j \wedge @_i\langle\textsc{Effect}\rangle k \rightarrow @_j k$
d. $@_i\langle\textsc{Origin}\rangle j \wedge @_i\langle\textsc{Origin}\rangle k \rightarrow @_j k$
e. $@_i\langle\textsc{Patient}\rangle j \wedge @_i\langle\textsc{Patient}\rangle k \rightarrow @_j k$

Without any further constraints like (31), a dependency relation δ acts as a free modifier.

Abstractly, a predicate-valency structure then takes the form as in (33) for a verb with a valency frame consisting of dependency relations $\delta_1, ..., \delta_i$. E is an *eventuality nucleus* and $\overline{p_1}, ..., \overline{p_i}$ are *structured objects*. Both terms are described in more detail below.

(33) $(E \wedge \mathbf{verbal - predicate} \wedge \langle\delta_1\rangle(\overline{p_1}) \wedge ... \wedge \langle\delta_i\rangle(\overline{p_i}))$

A little reflection on the nature of the arguments (variables) clarifies what I mean by a structured object. In line with the discussion in the previous chapter, these arguments are *discourse objects*, consisting of a discourse referent and its conditions. A structured object captures exactly that - it is a formula built from a nominal (the discourse referent) conjoined with one or more propositions (the conditions).

Definition 7 (Structured objects). *A structured object* $\overline{\varphi}$ *is a formula that is a conjunction of a nominal and one or more propositions:* $\overline{\varphi} = i \wedge \phi_1 \wedge ... \wedge \phi_n$. ⊛

The eventuality nucleus I use here is a formalization of Moens and Steedman's discussion of tense, aspect and modality. In the next section, I first present their discussion, based on Steedman's (2000b), and then the formalization.

3.3 VERBAL TENSE AND ASPECT

Verbs, together with their modifiers, convey propositions - propositions that are (usually) about the world around us.

In this section, I briefly discuss Vendler's Aktionsarten, here called aspectual categories, and then continue with Steedman's discussion relating aspectual categories to morphological tense and aspect (2000b) (based on earlier work with Moens, (Moens and Steedman, 1988)). Steedman describes a model that can be conceived of as elaborating particular ideas present in Kuryłowicz's (1964) discussion of tense and aspect. Since the discussion of tense and aspect in (Sgall et al., 1986) appears to be fashioned in a way similar to Kuryłowicz, we would like to advance Steedman's theory as a suitable explication and elaboration of the ideas discussed in (Sgall et al., 1986) (cf. also Hajičová and Panevová's (1969) and Panevová's (1980)).

I should like to start the discussion of tense and aspect by making it clear what we are talking *about*. As Steedman points out in (2000b), there are essentially *three* different types of issues. First of all, there is the issue of *temporal ontology*, which concerns the various kinds of events and states we may want to discern. Secondly, there are issues of *temporal relation*, determining what kinds of relations could be predicated over such events and states. These relations may be purely temporal, signifying temporal order, overlap, or inclusion; or they may point to causal, teleological, or epistemic relationships that hold between events or states, (Steedman, 2000b)(p.1).

Finally, the examples in (34)-(36) illustrate that some temporal relations might induce a dependence on the larger context in which the sentence is uttered. To be able to integrate this point into our discussion, we need to distinguish *temporal reference* from temporal relations and temporal ontology.

(34) **English**
Kathy will read the entire book.

(35) **English**
Kathy will read the entire night.

Whereas in (34) the direct object "the entire book" expresses a **Patient**, "the entire night" in (35) expresses a **Time:How Long**. As Sgall *et al.* note in (1996), inflectional languages often allow for the accusative case to be used in both these ways.

However, the **Time:How Long** dependency relation in (35) triggers a presupposition similar to those found with *when*-clauses, as discussed for example by Steedman in (2000b)(p.18ff).

(36) When Nixon was elected, Chapman breathed a sigh of relief. (Steedman, 2000b)(p.16)

The use of the past tense in (36) demands that there is an identifiable past reference point, either identified in the sentence itself by a temporal adverbial or by the preceding discourse. The **Time:When** dependent provides such a reference point, supposing that the hearer knows when Nixon was elected.

3.3.1 TEMPORAL ONTOLOGY

As the basis for our temporal ontology we use the taxonomy of action-types like Vendler (1967), or Kenny (1963). Vendler (1967) provides us with a classification that perceives of the propositions expressed by verbs and their modifiers, as different action-types or *aspectual categories.* As Dowty discusses in Chapter 2 of his (1979), Vendler's classification of verbs can be traced back to work as early as Aristotle, and bears similarities to work by for example Ryle. What sets Vendler's classification apart from the rest is that Vendler's was the first attempt "to separate four distinct categories of verbs by their restrictions on time adverbials, tenses, and logical entailments" (Dowty, 1979)(p.54).

The idea to conceive of the aspectual categories as classifying the *propositions* that verbs express rather than the verbs themselves does not originate with Vendler - as Steedman points out in (2000b), this reinterpretation of Vendler's theory is due to Dowty and to Verkuyl.

Vendler identified four types of aspectual categories, namely *achievement*, *activity*, *accomplishment*, and *state* (see Ch.4 of Vendler's (1967)). Following Steedman's discussion in (2000b), we can describe these types as follows.

An achievement is a category of event that is characterized as being instantaneous, and by resulting in a distinct change in the world. Verbal propositions expressing an achievement can be detected by the fact that they can be combined with adverbials that express a (reference to a) specific point of time (**Time:When**), like **English** *in*-prepositional groups (37), but cannot be combined with adverbials that express a duration over a period of time (notably, **Time:For How Long**) like **English** *for*-prepositional groups (38). Furthermore, verbs that realize an achievement do not carry a factive entailment under the progressive (39), and -at least in Germanic languages- they can be combined with the perfect (40):

(37) **English**
Christopher reached the top of the hill [in two hours $]_{Time:When}$

(38) **English**
Christopher reached the hilltop [for two hours $]_{Time:For\ How\ Long}$[11]

(39) **English**
Christopher is arriving to the top of the hill ($\not\models$ Christopher will have arrived to the top of the hill)

(40) a. **Dutch**
Christopher heeft de top van de heuvel bereikt.

b. **German**
Christopher hat den Gipfel des Hügels erreicht.

c. **English**
Christopher has reached the top of the hill.

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[11] Whereby we do not understand "for two hours" as meaning "two hours ago".

Vendler points out that achievements should not be confused with the different category of accomplishments. Consider the following examples (41) and (42) which Vendler discusses in (Vendler, 1967)(p.104):

(41) **English**
It took him three hours to reach the summit.

(42) **English**
He wrote a letter in an hour.

Example (42) illustrates an accomplishment. Saying that writing the letter took an hour implies that the writing of that letter went on during that hour. Vendler contrasts this to example (41), which is an achievement. Even though one may say that "reaching the summit" took three hours, it surely isn't implied that the act of reaching took three hours: The *climbing* towards the summit, eventually culminating in reaching it, took three hours.

Concisely put, what distinguishes an accomplishment from an achievement is that an accomplishment is extended over time. Steedman illustrates the difference on *writing a sonnet* and *finishing a sonnet.* Even though formally both achievements and accomplishments allow for the same modifers, the entailments thus differ. With an accomplishment, the time span is *part of* the event of writing (42). Similarly, it is part of the event of climbing (43), whereas we do not consider the event of reaching to be taking three hours (41).

(43) **English**
Christopher climbed to the summit in three hours.

The contrast that we find between the entailments of achievements and accomplishments led Verkuyl and Dowty to propose that accomplishments should be regarded as composites of an activity and a culminating achievement (Steedman, 2000b)(p.8).

Whereas both achievements and accomplishments result in a reasonably well-marked culmination point, *activities* do not. Activities are extended in time, but they do not result in a very distinct change in the world. As such, they go well with **English** *for*-prepositional groups (expressing **Time:For How Long**) (44) but not with **English** *in*-prepositional groups (45). Furthermore, the progressive does carry a factive entailment here, unlike the case of achievements and accomplishments (46).

(44) **English**
Christopher climbed [for two hours]$_{Time:For\ How\ Long}$.

(45) **English**
Christopher climbed [in two hours]$_{Time:When}$.

(46) **English**
Christopher is climbing ($\models$ Christopher will have climbed).

Finally, Vendler distinguishes the category of *states*. Steedman describes states as lacking definite bounds, and as being inherently non-dynamic, whereas Dowty characterizes states by drawing a parallel between the contrast between states and activities on the one hand, and Lakoff's distinction between *stative* and *non-stative*. Straightforward examples of verbs that signify a state are given in (47) through (49).

(47) **English**
Kathy is a genius.

(48) **English**
Elijah believes in the existence of UFOs.

(49) **English**
Christopher is tall.

Also considered as states are certain "predications of habitual action" (Steedman, 2000b)(p.8), like (50) and (51):

(50) **English**
Kathy works at the university.

(51) **English**
After Elijah gets up, he makes a cup of coffee.

Now, the question may arise whether the aspectual categories above are intrinsic properties of verbs and their lexical meanings. Dowty (1979) discusses a variety of examples that show that this is clearly not the case (cf. his §2.2.5). See also (Verkuyl, 1973). For example, a verb that prototypically expresses an activity, like **English** *walk*, realizes an accomplishment when it is modified by either a location (**Locative**) or a destination (**Direction:Where To**):

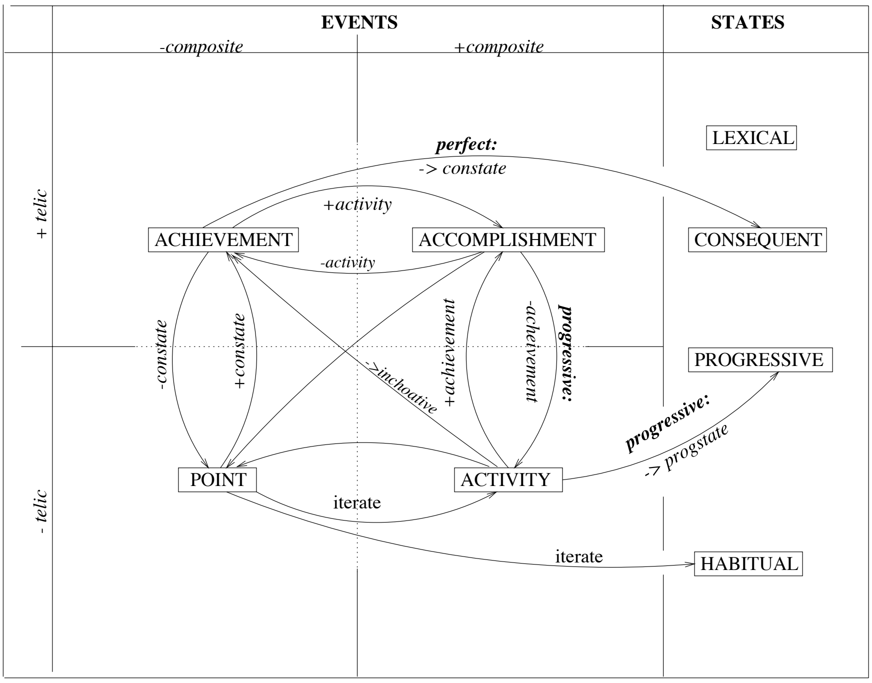

Figure 3.1: A scheme of aspectual coercion, adapted from (Moens and Steedman, 1988)

(52) John walks $\begin{cases}\text{a mile.}\\ \text{to the park.}\end{cases}$ (Dowty, 1979)(p.60)

The crucial point here is that aspectual *change* arises from the nature of the verb's modifiers - i.e from the *dependency relations* involved. Both Verkuyl and Dowty pointed this out - to quote (Steedman, 2000b)(p.9), "some similar protean shifts in aspectual category of the event conveyed by a sentence depend[..] upon the semantic type of the nominal categories involved as arguments of the verb."

Before I review the fundamental role that dependency relations appear to play in aspect and aspectual change, I first discuss Moens and Steedman's scheme of aspectual change or aspectual coercion as originating from their (1988).

The scheme in Figure 3.1 reflects how we can conceive of aspectual change or "coercion" as semantically guided transitions between Vendlerian aspectual categories or aspectual categories. The scheme divides the aspectual categories into states and events, with the latter again being divided

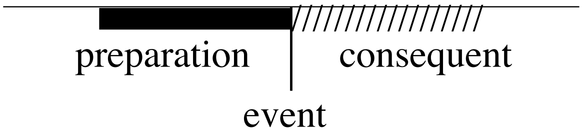

Figure 3.2: The event nucleus

further into the familiar categories *achievement*, *accomplishment*, *activities*, and a forth atomic telic category, *point*. As Steedman explains, the real significance of *point* is that it acts as a way-station "where the internal structure of an event is 'frozen' on the way to being iterated or turned into a consequent state by the perfect." (2000b)(p.11) The division of the events is based on two semantic features - *telicity* and *decomposability*. Steedman describes telicity as the association with a particular change of state, whereas decomposability regards the possibility to decompose into sub-events (rather than having to do with temporal extent or duration).

The possibilities to change from one type of aspectual category to another is depicted by arrows. Each arrow is annotated with an indication of the nature of the semantic change, like *iterate*. Additionally, a change may be conditioned by lexical meaning or form, such as the perfect or the progressive. These conditions are indicated in bold-face.

An interesting feature of aspectual change is that they all seem to reflect an underlying semantics in which events of all kinds are associated with a *preparation*, being the activity that brings the event about, and a *consequent*, which is the ensuing state that the activity results in. To represent this semantics Moens proposed in his dissertation in 1987 to use a tripartite structure called the *event nucleus*, see Figure 3.2.

We consider the event nucleus to be composed of the aspectual categories as given in Figure 3.1. Particularly, the event is associated to a preparation which relates an activity to the event that it that brings about, and a consequent, connecting the event to the ensuing state. The event itself is thus a (possibly complex) achievement. Finally, as Steedman points out (2000b)(p.11), the event nucleus itself is closely related to the category of accomplishments.

To round off this brief discussion of Vendler's aspectual categories, we would like to have a closer look at the relation between these categories, and different dependency relations (which each are considered to impart a different meaning). For example, we already saw above that an achievement, not being extended over time, can take a dependency relation like **Time:When** but not one that inherently expresses an interval, like **Time:For How Long**. Although this is of course most clearly illustrated on dependency relations of a temporal nature, it is also true that achievements do not go with a dependency relation like **Extent**. **Extent** is not a temporal dependency relation, but still embodies an idea of an extended period of time, and can therefore be considered inappropriate (cf. (Dowty, 1979), p.60).

But not only are there interesting connections between the aspectual category a proposition or more precisely, a saturated predicate-valency structure, expresses and the dependency relations occurring in that predicate-valency structure. Also *aspectual change* elucidates such connections.

For example, let us reconsider the example of aspectual change illustrated in (52). There we considered how an activity, which lacks a clear culmination point, can be changed into an accomplishment by basically *adding a dependency relation* that would express (in one way or the other) such a culmination point. In the example we used **Locative** and **Direction:Where To**, after (Dowty, 1979). Surely, these are not the only possible ones. To change from activity to accomplishment, we can also consider **Time:Till When** (53):

(53) **English**
Activity: Kathy walked
Accomplishment: Kathy walked [till dawn]$_{Time:Till\ When}$

Similar connections can also hold (under certain conditions) between other aspectual categories. For example, consider the following example:

(54) **English**
The visitors arrived.

In the absence of any further specification of when, or during what period, the visitors arrived, the sentence in (54) conveys an achievement. However, by adding a modifier expressing a duration, like **Time:How Long**, the plurality of the **Actor** "Visitors" enables a more 'distributed' reading in which the visitors are arriving all through the night - which is an activity (after (Steedman, 2000b),p.10):

(55) **English**
Achievement: The visitors arrived.
Activity: The visitors arrived [through the night]$_{Time:How\ Long}$.

The same observation holds for other Indo-European languages as well. (Note the change of verbal aspect in (59).)

(56) **German**
Achievement: Die Besücher kamen an.
Activity: Die Besücher kamen an [während der Nacht]$_{Time:How\ Long}$.

(57) **Dutch**
Achievement: De bezoekers kwamen aan.
Activity: De bezoekers kwamen aan [gedurende de nacht]$_{Time:How\ Long}$.

(58) **French**
Achievement: Les visiteurs arrivaient.
Activity: Les visiteurs arrivaient [pendant la nuit]$_{Time:How\ Long}$.

(59) **Czech**
Achievement: Hosté přišli.
Activity: Hosté přicházeli [celou noc]$_{Time:How\ Long}$.

The examples below illustrate more aspectual changes that can be brought about by adding particular modifiers: **Result** (60)[12], **Purpose** (61), and **Condition** (**Counterfactual**) (62).

(60) **English**
Activity: Elijah swam.
Accomplishment: Elijah swam [so that Jaws did not catch him]$_{Result}$.

(61) **English**
Accomplishment: Christopher made a chair.
Activity: Christopher made a chair [so that he had one to sit on]$_{Purpose}$.

(62) **English**
Activity: Christopher ran.
Achievement: Christopher ran [but didn't make it in time]$_{Counterfact.}$.

Of course not *all* aspectual change is brought about by adding particular dependency relations, nor is it even the case that all aspectual categories are

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[12] Cf. also the factives in Dowty's table on accomplishments, (1979)(p.69-71).

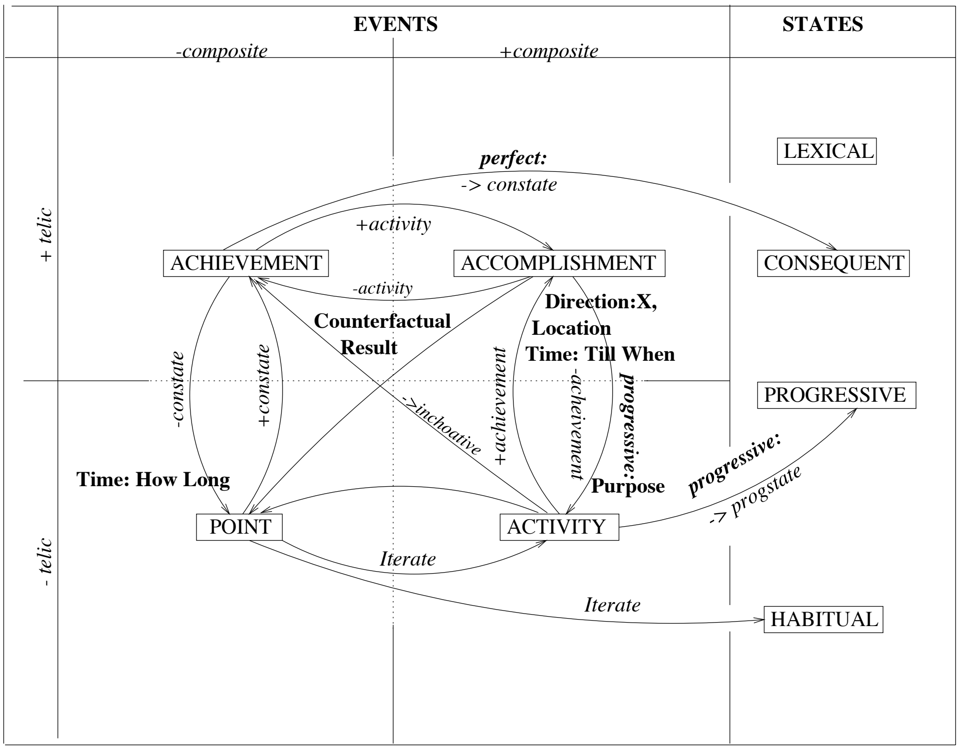

Figure 3.3: Aspectual coercion, including effects of using particular dependency relations

realized by verbs that take (only) particular types of modifiers. For example, languages employ particular verbal *forms* to realize aspect, usually phrased in terms of binary oppositions like *perfective/imperfective*, and possibly the opposition *iterative/resultative*. For example, iterativity is expressed productively in Czech, using the infix $-va-$ (3.3.1):

(63) **Czech**
psát (be writing), *psávat* (write, repeatedly)
psát (be writing), *napsat* (write)
dávat (be giving), *dát* (give)

The scheme of Moens and Steedman includes the effects of the above aspectual forms, for example one can bring about a change from an achievement to consequent state by using the perfective. Below I present the scheme again in Figure 3.3, but now including all the aspectual changes as brought about by adding particular dependency relations, as I discussed above.

3.3.2 TEMPORAL RELATIONS

In the above discussion we established an ontology of temporal/action types, called aspectual categories. We now turn to the linguistic system that covers *relations* between these different types. In most languages, these *temporal relations* consist in tense, aspect, and modality.

My interest here is mainly in pointing out a basic perspective on these subsystems, rather than delving too deep into language-specific detail. The purpose is to *clarify* the basic perspective - in the later chapters, I show that the framework accommodates this perspective, thus *enabling* one to model any such system for a given language. There is a very substantial discussion in the literature on systems for tense and aspect - see for example Steedman's (1997; 2000b) for overviews and references, Kuryłowicz's (1964) for a fundamental typological discussion of tense and aspect in indo-european languages.

To describe tense, we adhere to a model based on Reichenbach's work (1947) that is used in general. Reichenbach advanced in (1947) the view that, linguistically speaking, tense does not quantify over *two* times, like a "now" and a "then", but over *three* times: the speech time (S), the event time (E), and the reference time (R).

The speech time S is obviously the time at which the sentence is uttered. The event time E is the time (or *temporal extension*) of the expressed proposition - the ontology we discussed above is an ontology of E. Finally, the reference time R is the time (or context) that we are talking *about*, or from which point the event E is viewed.

Particularly *when*-clauses are illustrative of such reference-setting:

(64) **English**
When Elijah arrived to the party in his cowboy boots, everybody starting laughing.

The different tenses a language distinguishes can be defined in terms of R, S, E, and their mutual relationship (ordering/equivalence). For example, we have for English the following (cf. (Steedman, 2000b) and (Hajičova and Panevová, 1969)):

(65) a. Christopher saw Elijah. *Simple Past*, $E = R < S$
b. Kathy wins! *Present*, $E = R = S$

c. Elijah goes to Timbuctoo by bike. *Simple Future*, $S \ < \ R = E$

Or, for a more diagrammatic representation, see Figure 3.4.

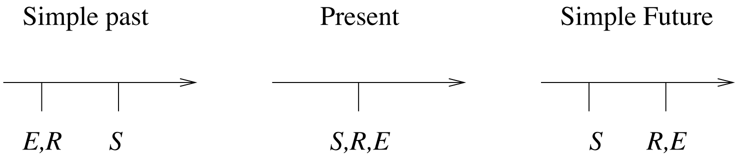

Figure 3.4: Reichenbachian model of basic English tenses

This model has been extended to cover a large variety of different tenses, for example see (Steedman, 2000b). Here, we continue with integrating the aspectual opposition *perfective/imperfective* (or perfective/progressive) into the picture established for tense.

Both perfective and progressive compose with tense. When we combine the perfective with the tenses as in (65), we obtain realizations of the Consequent State, with R in that state, derived from E which in and by itself would have realized an achievement - cf. again the diagram in Figure 3.1.

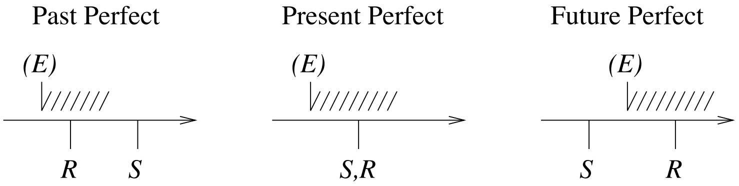

Figure 3.5: The English perfect

In the case of the progressive, R lies in the Progressive Sate, with E an activity.

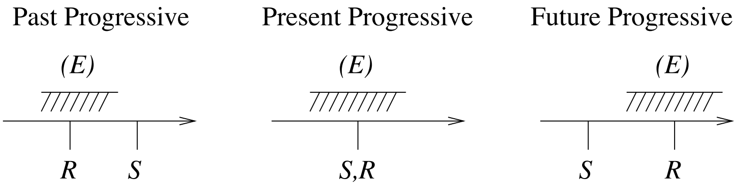

Figure 3.6: The English progressive

Interesting possibilities arise when we consider aspectual change again. Aspectual change may result in the derivation of the core event E from a different category E'. For example, consider the event of *winning the* *race*, which is an achievement. This event can be turned into an activity, if it becomes associated to an event that is prototypically an activity, like *running*. According to Steedman, "[t]he progressive can then strip off the original achievement, to leave the bare activity, which is then mapped onto the corresponding state, which is predicated of R, the time under discussion."(2000b)(p.24). Being able to change the aspectual category in this way explains, according to Steedman, the possibility of futurate progressives, like in (66).

(66) a. I am winning! *Present Futurate Progressive*
b. I was winning! *Past Futurate Progressive*

The above discussion depicted tense and aspect, quite literally, in terms of a single "time-line". Modality enables us to consider the flow of time not as a single, deterministic history, but as a road on which we can follow alternative directions. Technically, we usually represent such a model of the flow of time as a transition graph where, at each state, there are several alternative continuations - the *branching time model*, cf. also (Gamut, 1991).

We distinguish two different types of modality, namely *epistemic modality* and *deontic modality*. Epistemic modality has to do with the necessity, possibility, inferability, or predictability of the proposition that is expressed by the main verb (that is being modified by the modal expression). For example,

(67) a. Elijah must be crazy to have bought those boots. (*Necessity*)
b. Kathy may want to throw them away. (*Possibility*)
c. That will infuriate Elijah. (*Inferability*)

Deontic modality regards the feasibility or permissibility of the proposition, or the ability, desirability or obligation on part of the **Actor**. Thus, we have for example

(68) a. Elijah must buy decent shoes. (*Obligation*)
b. Christopher can do the bugaloo. (*Ability*)
c. Kathy may park her car here. (*Permissibility*)
d. This planning can be fulfilled. (*Feasibility*)
e. Elijah wants to look like a cowboy. (*Desirability*)

Sgall *et al.* discuss in (1986) a different but comparable approach to modality (p.170ff). The approach employs Benešová(1972)(with minor modifications), and is based on an analysis of modality in Czech.

As Sgall *et al.* point out, it appears appropriate (at least for Czech, and arguably for English as well, as the authors illustrate) to distinguish the following values: For *modal properties*, necessity, possibility, and desirability; and for the *source of modality*, circumstance, a subject other than the **Actor**, or the **Actor** him-/herself. A combination of values for these two factors determines the actual modality of a verb. (Sgall et al., 1986) mentions the following examples for English (p.170-171).

(69)

necessity+{circumstance, subject o.t. **Actor**}	*have to*
necessity+{**Actor**}	*must*
desirability+{circumstance, subject o.t. **Actor**}	*should, ought to*
desirability+{**Actor**}	*want*
possibility+{circumstance, **Actor**}	*can*
possibility+{subject o.t. **Actor**}	*may* (permissive)

The modalities presented in (Sgall et al., 1986) are comparable to most of the deontic modalities that Steedman (2000b) discusses.

(70)

(Sgall et al., 1986)	*(Steedman, 2000b)*
necessity + {**Actor**}	Obligation
desirability + {**Actor**}	Desirability
possibility+{**Actor**}	Ability
possibility + {subject o.t. **Actor**}	Permissibility

If we allow for Steedman's Desirability to hold for propositions as well, then that would cover desirability + {subject other than **Actor**}. Further parallels can only be drawn if we include a concrete notion of *circumstance* in (Steedman, 2000b).

To model modality, I presume familiarity with the notion of Kripke models, their role in modal logic, and how a branching time model can be constructed using a modal logic with multiple modalities. For more on basic modal logic and its model theories, see Bull & Segerberg (1984) and Van Benthem (1984), whereas the interaction between tense and modality is discussed in detail in Thomason (1984) and Gamut (1991).

3.3.3 TEMPORAL REFERENCE

Finally, with tense and aspect indicating different ways of putting the Reichenbachian reference point R on the time-line, and with modality making that time-line into a more complex, braching structure, the question arises how we can represent and access R. In other words, we should turn to our third issue, that of *temporal reference.*

Let us first consider a few examples that can be taken as indicative not only of the use but also of the nature of temporal reference. The examples are after (Steedman, 2000b)(Chapter 4).

(71) a. [When Elijah took Kathy's pawn $]_{Time:When}$, she took his queen.

b. Elijah took Kathy's pawn. Kathy took Elijah's queen.

The **Time:When**-dependent in (71a) establishes a reference point for the main clause to refer to anaphorically, much in the same way as the definite noun like Kathy constitutes a referent for the pronoun *she* in the main clause. This provides an interesting difference to the first sentence in (71b). The **Time:When**-dependent in (71a) presupposes that it is *possible* for the hearer to establish the reference point indicated by the dependent. The past tense of the first sentence in (71b), on the other hand, *requires* that this reference point has already been established.

Obviously, the state that the **Time:When**-dependent in (71a) refers to is not the same state that the main clause in (71a) refers to. Rather, the state expressed by the main clause resulted from the state refered to by the **Time:When**-dependent. The situation can also be different, as (72) illustrates. Here, the **Time:When**-dependent establishes the state that the stative main clause is about.

(72) When Elijah took Kathy's pawn, he did not know it was protected by one of Kathy's knights.

Rather than moving the action on, as in (71a), or using a stative to elaborate on the reference point (72), we can also predicate an event of the original reference point - (73).

(73) When Elijah took Kathy's pawn, he used a rook.

Finally, as for example (Partee, 1984) points out, a **Time:When**-dependent need not establish a reference point that precedes the main clause's. (74) illustrates this.

(74) When Elijah won his only game against Kathy, he used the John Wayne opening.

Steedman argues that phenomena like the ones illustrated in (71) through (74) can arise because the temporal referent is not strictly temporal. Instead of being simply a reference to a point or an interval, it is a reference to an event nucleus. To repeat what was said on page 49 (see also Figure 3.2), the event nucleus consists of a preparation (an activity), a consequent (a state), and the core event (an achievement). Or, to use Steedman's words, "The preparation of an event is the activity that led to the state in which that achievement took place." (2000b)(p.55)

Reflecting on the examples above, the **Time:When**-dependent thus identifies an event nucleus, and the main clause is related to an aspect of that event nucleus. For example, the main clause can be related to the core event of the event nucleus as a property of the initial state (72), or as a property of the transition itself (73). The main clause can also be related to the preparation of the event nucleus, as in (74). Finally, if we consider modal frames, then the main clause in (71) is just one of the possible subsequent actions accessible from the consequent state of the event nucleus identified by the **Time:When**-dependent.

The conception of temporal reference as the identification of an event nucleus is important to the definition of the semantic import of -notably- temporal dependency relations. But, before we are able to do so, I first have to establish a logical account of Moens & Steedman's event nucleus and its role in their model of aspectual change and aspectual categories. This is the aim of the next section.

3.3.4 A FORMALIZATION OF MOENS & STEEDMAN'S MODEL

An important aspect of Moens & Steedman's model of aspectual change and aspectual categories is its emphasis on using a *rich temporal ontology.* This raises an interesting issue for its formalization, as most formal accounts argue for either a point based semantics or an interval based semantics.[13]

From Moens and Steedman (1988) it should be clear that we actually need both. To my knowledge, Blackburn, Gardent and De Rijke present in (1993) the first logical model in which such a combined ontology was worked out, specifically aimed at formalizing the event nucleus. Their proposal is to define a *back-and-forth structure* (BAFs) in which one (quite literally) moves back and forth between an *interval structure* (including minimal, "point-like" intervals) and an *eventuality structure*. In a BAF, the interval structure models temporal extent, providing the temporal structure, whereas the eventuality structure represents eventualities and the possibility of one eventuality giving rise to another. The crucial ingredient of a back-and-forth structure is a set of two relations that link these structures: a relation z, from the eventuality structure to the interval structure, returns the temporal extent of an eventuality, whereas the other relation $\mathcal{Z}$ relates an interval to the eventualities that 'take place' during that interval. Figure 3.7 represents this diagrammatically, and Definition 8 gives Blackburn *et al.*'s basic definition of BAFas provided in (1993)(§3).

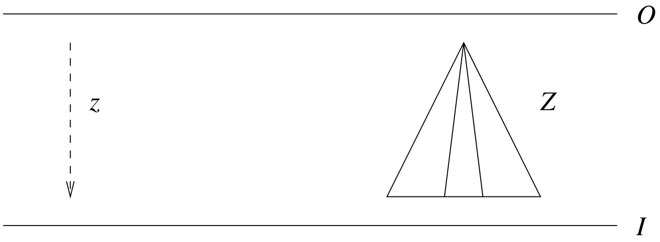

Figure 3.7: Back-and-forth structures

Definition 8 (Simple back-and-forth structures). interval structure $\mathcal{I}$ *is a triple* $\langle I, <, \sqsubseteq \rangle$ *as defined in (Van Benthem, 1991b).* $\mathcal{I}$ *is a set of (possibly point-like) intervals,* $<$ *models the temporal precedence relation, and* $\sqsubseteq$ *is the subinterval relation. For simple BAF, interval structures are* linear *and atomic. An* eventuality structure *of signature* $\mathcal{E}$ *is a triple* $\mathcal{O} = \langle O, \mathtt{GRiTo}, \{P_e\}_{e \in \mathcal{E}} \rangle$*.* O *is a non-empty set of* eventuality occurrences*,* `GRiTo` *is a binary relation on* O*, and* $\{P_e\}$ *is a set of* unary relations *on* O*. It is assumed that* $\mathcal{E}$ *is not empty. If* e `GRiTo` e' *then we say that* e gives

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[13] For an interesting, though perhaps by now slightly outdated, argument against interval based semantics and for a point based one, see Tichý's (1981; 1985). In (1981), Tichý presents his own model of tense and aspect, using transparent intensional logic.

rise to e'. *The unary relations* P_e *can be thought of as eventualities - for example* $running(e)$ *specifies* e *as an eventuality of running.*

A back-and-forth structure *of signature* $\mathcal{E}$ *is a quadruple* $\langle \mathcal{O}, z, \mathcal{Z}, \mathcal{I} \rangle$*, with* $\mathcal{O}, \mathcal{I}$ *as defined above.* z *is a function from* O *to* I *preserving the relation* *GRiTo: if* e GRiTo e' *then* $z(e) < z(e')$*. Thus,* z *is an order-preserving morphism from* O *to* I *- it is this morphism that synchronizes* $\mathcal{O}$ *and* $\mathcal{I}$*.* $\mathcal{Z}$ *is a relation with domain* O *and range* I *defined by* $e\mathcal{Z}i$ *iff* $i \sqsubseteq z(e)$*. Thus, it is assumed that all eventualities are* downward persistent *to subintervals.* $\circledast$

Example (A simple model of the English present perfect). To illustrate the basic intuitions behind simple BAFs as defined above, let us consider the English present perfect as examplified in (75).

(75) **English**
Elijah has spilled his coffee.

First, let us recall the Reichenbachian model of the English present perfect - repeated below.

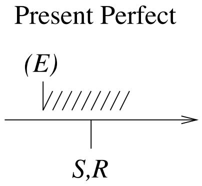

Figure 3.8: Reichenbachian schema of the English Present Perfect

As Moens & Steedman argue (cf. p.24,(2000b)), the reference point R lies within a consequent state, derived from the original event E which is an achievement. Instead of the Reichenbachian diagram as in Figure 3.8 we thus get a diagram as in Figure 3.9, including Moens & Steedman's event nucleus.[14]

To model these intuitions in a BAF, we first establish a language. To keep matters simple, we take a vocabulary that consists of all the elements in $\mathcal{E}$, written as $p, q, r, ...$ called *eventuality symbols*, and a unary operator Perf. If ε is an eventuality symbol, then Perf ε is a well-formed formula; and nothing else is.

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[14] Note that the schema in Figure 3.9 has the event E *bracketed.* This signifies that the perfect does not fully determine the position of E with respect to R, S - see (Steedman, 2000b)(p.24).

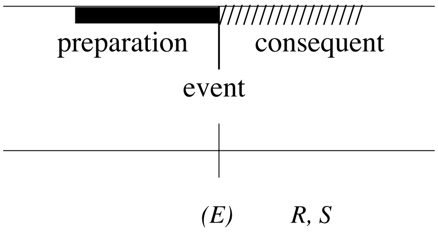

Figure 3.9: Moens & Steedman's schema of the English Present Perfect

Subsequently, let $\mathsf{B}{=}\langle\mathcal{O},z,\mathcal{Z},\mathcal{I}\rangle$ be a BAF. For all intervals i, and all eventuality symbols ε, we define:

(76)

$$\begin{array}{lll} \mathsf{B},i \Vdash \textsc{Perf}\ \varepsilon & \text{iff} & \exists i'\exists e'\exists e(i' < i \quad \& \\ & & i' = z(e') \quad \& \\ & & e' \ \in \ P_{\varepsilon} \quad \& \\ & & e' \ \texttt{GRiTo}\ e \quad \& \\ & & e\mathcal{Z}i) \end{array}$$

Consider again the sentence in (75). In the simple language defined here, this takes the form as in (77).

(77) Perf(*Elijah spills his coffee*)

Now let us see what this does, given the semantics (76). If we evaluate (77) on an interval i in B, then we must 'complete a square' through the back-and-forth structure leading eventually back to i. Thus, we first move back to an interval i' that preceeds i ($i' < i$), and which is the temporal extent of an event e' ($i' = z(e')$). The event e' is of the correct 'kind', that is to say that it is an event of spilling coffee ($e' \ \in \ P_{\varepsilon}$). Moreover, e' gives rise to e (e' `GRiTo` e), which $\mathcal{Z}$ relates to i ($e\mathcal{Z}i$). Intuitively, we can understand e to be the consequence of the event of spilling coffee, e.g., Elijah's trousers being dirty.

We can couple this back to Moens and Steedman's diagram in Figure 3.9 in a straightforward manner: The interval i is the time of speech (S), i'

is the event time (E), and e is the consequent state arising from the event that is being described, namely e'. ⊛

Naturally, simple BAFs give only a rather rudimentary picture. Blackburn *et al.* extend their definition of simple BAFs, enriching the eventuality structure by distinguishing different sorts of events. The sortal distinctions they introduce, and the additional relations that can hold among them, are motivated by the Vendlerian aspectual categories that Moens and Steedman capture in their diagram.

Remark 6 (Essential intuitions behind BAFs). Before I continue with describing how one could employ a sorting strategy (familiar from the discussion of hybrid logic in the previous chapter), I will clarify what I see as the essential intuitions behind BAFs and the kind of model they define (as illustrated above).

(78) a. *Separate time from event structure*: This separation gives rise to the (intuitively correct) perspective that an event *has* a temporal extent, rather than that it *is* a particular stretch of time.

b. *Complete the square*: If there exists a possibly complex relation between two intervals, then there needs to exist another, again possibly complex relation between the events whose temporal extent is signified the respective intervals.

When elaborating BAFs into richer structures, it is the above intuitions that we need to bear in mind. The second intuition acts as a requirement on establishing a coherent picture. The first intuition enables us to take the sorting strategy to the (logical) extent where we can consider different sorts of time to be defined in parallel to different sorts of events. ⊛

As said, Blackburn, Gardent and De Rijke extend the simple BAFs by considering more sorts in the eventuality structure. However, in the light of Blackburn's earlier work on tense logic (1990; 1994; to appear) it is perhaps surprising that they do not make any explicit use of hybrid logic. The advantages, I would argue, would be that couching BAFs on hybrid logic results in a more perspicuous formalization, and that it opens the obvious possibility to include the work done on formalizing tense logics in hybrid logic. Furthermore, using hybrid logic also has a distinct advantage for my purposes here, as it would mean that the model could immediately be integrated in the overall approach to representing meaning. It is with these thoughts in mind that the formalization below is done using hybrid logic.

To begin with, consider two sets of sorts of nominals, $\mathcal{E}$ and $\mathcal{S}$. In keeping with Moens and Steedman's proposal, $\mathcal{E}$ consists of the sorts achievement, accomplishment, point, and activity, whereas $\mathcal{S}$ contains consequent, progressive, and habitual. A nominal of sort $\mathcal{S}$ is typeset as S.

To relate different nominals, I simply follow Blackburn *et al.* (1993) and Steedman (2000b) in considering the preparation and the consequent of the event nucleus as *relations*. If we understand these relations as two modal operators Prep and Cons, then the (basic) event nucleus can be represented as in (79).

(79) $@_{activity}\,\langle\textsc{Prep}\rangle\, achievement$
$\wedge\, achievement$
$\wedge\, @_{achievement}\,\langle\textsc{Cons}\rangle\, consequent$

Both Prep and Cons are of course modalities defined on the eventuality structure of a BAF. To abbreviate a representation like in (79), we write *ach* for *achievement*, *act* for *activity*, and *con* for *consequent*.

Now consider again a Priorian tense logic as illustrated earlier, in Example 2.1 on page 20. If we take the Simple Past, then the relations between E, R and S can first of all be specified as in (80): both E and R are in the past of S, and for the Simple Past it holds furthermore that E and R coincide ($@_E R$).

(80) $S \wedge \langle \mathsf{P} \rangle E \wedge \langle \mathsf{P} \rangle R \wedge @_E R$

A temporal perspective like in (80) is interpreted on the interval structure of a back-and-forth structure. The interesting question is of course, how to integrate (79) and (80)?

The answer is *relatively* simple. First of all, note that "[t]he ontology of events [...] should be viewed as an ontology of the Reichenbachian E"(Steedman, 2000b)(p.21). Furthermore, we can leave S implicit, as we already saw earlier in the representation of the discourse (16), given in (17) (see page 28).[15] Thus, intuitively, we could create a representation as in (81), with ref being the temporal nominal corresponding to R, and "finish"

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[15] Essentially, the model theory takes care of S as the vantage point from which a formula is evaluated.

understood as an achievement. In (81c), $\mathcal{E}$ further abbreviates the nucleus (79), such that the formula only mentions the relevant parts.

(81) a. Kathy finished a letter.

b. $\langle \mathsf{P} \rangle (@_{act}\ \langle \textsc{Prep} \rangle\ ach \& @_{ach}\ \langle \textsc{Cons} \rangle\ cons \& @_{ach} ref \& @_{ach} \mathbf{finish})$
$\rightarrow\ (@_{act}\ \langle \textsc{Prep} \rangle\ ach \& @_{ach}\ \langle \textsc{Cons} \rangle\ cons \& @_{ach} ref \& @_{ach} \mathbf{finish} \& \langle \mathsf{P} \rangle ach)$

c. $(\mathcal{E}\ \wedge\ @_{ach} ref\ \wedge\ @_{ach} \mathbf{finish}\ \wedge\ \langle \mathsf{P} \rangle ach)$

There is one important observation to make about (81), and that is that we have slightly complicated the logical situation. Originally, tense operators like $\langle \mathrm{P} \rangle$ or $\langle \mathrm{F} \rangle$ operated on elements of the interval structure - whereas now they *seem* to be applied to elements that are interpreted on the *eventuality structure*. Their logical definition should rectify this, and we can do so in a straightforward manner by making use of z. That is, the interpretation of a tense operator $\langle \mathrm{T} \rangle \varepsilon$ is defined on $z(\varepsilon)$, i.e. the temporal extent of the event ε.

Definition 9 (Hybrid logical BAFs). *We begin by defining a* sorted eventuality structure, O_s. O_s *is a tuple* $\mathsf{O}_s = \langle \mathfrak{E}, \mathtt{GRiTo}, \textsc{Prep}, \textsc{Cons}, P \rangle$. $\mathfrak{E}$ *is the set of eventuality nominals, composed from two disjoint sets* $\mathcal{E}$ *and* $\mathcal{S}$. $\mathcal{E}$ *consists of the sorts achievement,accomplishment, point, and activity, whereas* $\mathcal{S}$ *contains consequent, progressive, and habitual.* $\mathtt{GRiTo}$ *is a function defined analogously to Blackburn* et al.*'s* $\mathtt{GRiTo}$ *function.* $\textsc{Prep}$ *and* $\textsc{Cons}$ *are modal operators for which it holds that* $\textsc{Prep} \subset \mathtt{GRiTo}$ *and* $\textsc{Cons} \subset \mathtt{GRiTo}$. $\textsc{Prep}$ *is a partial function with domain activity and range achievement, whereas* $\textsc{Cons}$ *is a total function with domain achievement and range state (cf. (Blackburn et al., 1993)).* P *is simply the set of propositional formulas that can hold at eventuality nominals.*

Furthermore, we define an interval structure I_s. I_s *is a tuple* $\mathsf{I}_s = \langle \mathfrak{I}, \mathrm{P}, \mathrm{F}, \textsc{During}, <, \sqsubseteq \rangle$. $\mathfrak{I}$ *is a (suitably sorted) set of nominals modeling temporal extent, with* $<, \sqsubseteq$ *to provide the basic temporal structure. The modal operators* P, F *are the familiar hybrid logical versions of the Priorian past and future operators (Blackburn, 1994; Blackburn, to appear), and* $\textsc{During}$ *is the modal reflection of* $\sqsubseteq$. *For all modal operators it holds that their (operational) semantics are defined in the context of a hybrid logical BAF: We allow* $\langle \mathsf{P} \rangle \varepsilon$ *with* $\varepsilon \in \mathfrak{E}$ *as a well-formed formula by defining the operational semantics of the modal operators using* z*, i.e. the interpretation of* $\langle \mathsf{P} \rangle \varepsilon$ *uses* $z(\varepsilon)$*. Thus, for example, we have that*

$$\mathsf{B}, i \Vdash \langle \mathrm{P} \rangle\ \varphi \quad \mathit{iff} \quad \exists j, e(e \in \mathfrak{E} \wedge j < i\ \wedge\ e\mathcal{Z}j\ \wedge\ @_e\varphi)$$

A hybrid logical BAF *is a HL-BAF* $\mathit{HB}{=}\langle \mathsf{O}_s, z, \mathcal{Z}, \mathsf{I}_s\rangle$*. The relations* $z, \mathcal{Z}$ *are defined as in Definition 8, and we require by definition that* $\forall e, i(i \sqsubseteq z(e) \leftrightarrow e\mathcal{Z}i)$*. Additionally, we have the following conditions, after (Blackburn et al., 1993). The operator* $\sqcap$ *connects two intervals.*

1. *z(*activity*) is a non atomic bounded interval in* $\mathfrak{I}$
2. *z(*achievement*) is a non atomic bounded interval in* $\mathfrak{I}$
3. *z(*accomplishment*) is a non atomic bounded interval in* $\mathfrak{I}$*, which is* separable *(Blackburn, 1990)(p.167) into two intervals i, i' such that i=z(activity), i'=z(achievement), i* $<$ *i', i* $\sqcap$ *i' = z(*accomplishment*).*
4. *z(*point*) is an atomic interval in* $\mathfrak{I}$
5. *z(*consequent*) is a non atomic, non bounded interval in* $\mathfrak{I}$
6. *z(*progressive*) is a non atomic, non bounded interval in* $\mathfrak{I}$
7. *z(*habitual*) is a non atomic, non bounded interval in* $\mathfrak{I}$

Finally, to be able to talk explicitly in a hybrid logic about the temporal extent ι *of a given eventuality* ε*, we define the sorted satisfaction operator* $@^I$ *such that for the equation* ${@^I}_\varepsilon\iota$ *it holds that* $\iota = z(\varepsilon)$*.* ⊛

Remark 7 (Representing English tense and aspect). With the above definitions at hand, it becomes a straightforward exercise to represent the basic English tenses, as we gave them earlier on in Figure 3.4 on page 54. Important to note is that we attach a tense operator to the nominal that is of the proper sort σ given the proposition φ being expressed.

(82) a. Simple Past, $E = R\ <\ S$: $(\mathcal{E}\ \wedge\ @_\sigma\varphi\ \wedge\ @_\sigma ref\ \wedge\ \langle\mathsf{P}\rangle\sigma)$
b. Present, $E = R = S$
c. Simple Future, $S\ <\ E = R$: $(\mathcal{E}\ \wedge\ @_\sigma\varphi\ \wedge\ @_\sigma ref\ \wedge\ \langle\mathsf{F}\rangle\sigma)$

To add aspect, we should make precise the interpretation of PERF and PROG. Blackburn *et al.* give in (1993) their basic definitions, formulated using hybrid logic in (83) below.

(83) a.

$$\begin{aligned}\mathsf{B}, i \Vdash \textsc{Perf}\ \varepsilon \quad \text{iff} \quad & \exists i' \exists e' \exists e (i' < i \quad \wedge \\ & i' = z(e') \quad \wedge \\ & @_{e'}\varepsilon \quad \wedge \\ & @_{e'}\langle \text{GR}\textsc{i}\text{T}\textsc{o}\rangle e \quad \wedge \\ & e\mathcal{Z}i)\end{aligned}$$

b.

$$\begin{aligned}\mathsf{B}, i \Vdash \textsc{Prog}\ q \quad \text{iff} \quad & \exists ach(@_{ach} q \wedge i \sqsubseteq {}^{+}z(ach)) \vee \\ & \exists progressive(@_{progressive} q \wedge i \sqsubseteq {}^{+}z(progressive))\end{aligned}$$

Here, $i \sqsubseteq {}^{+}j$ holds if the interval i is a proper interval of j with neither i's start nor end coinciding with that of j. For our present purposes, we consider $@_i\langle \textsc{During}\rangle j$ to be interpreted as $i \sqsubseteq {}^{+}j$. Given (83), it is easy to define for example the past progressive - see (84).

(84) $\mathsf{B}, i \Vdash \langle \textsc{Past}\rangle\langle \textsc{Prog}\rangle\varphi \quad \text{iff} \quad \exists j (j < i \ \wedge \mathsf{B}, j \Vdash \langle \textsc{Prog}\rangle\varphi)$

To round off these remarks, consider how we could represent the pair of example sentences as in (85), with their representations in (86).

(85) a. Christopher was writing a letter.
b. Christopher wrote a letter.

(86) a. $(\mathcal{E} \ \wedge \ @_{act}\mathbf{write} \ \wedge \ @_{ref}\langle \textsc{During}\rangle act \ \wedge \ \langle \textsc{Past}\rangle\langle \textsc{Prog}\rangle act$
$\wedge\ @_{act}\langle \textsc{Actor}\rangle(c \wedge \mathbf{Christopher})$
$\wedge\ @_{act}\langle \textsc{Patient}\rangle(l \wedge \mathbf{letter}))$
b. $(\mathcal{E} \ \wedge \ @_{act}\mathbf{write} \ \wedge \ @_{act}ref \ \wedge \ \langle \mathsf{P}\rangle act$
$\wedge\ @_{act}\langle \textsc{Actor}\rangle(c \wedge \mathbf{Christopher})$
$\wedge\ @_{act}\langle \textsc{Patient}\rangle(l \wedge \mathbf{letter}))$

When explaining how aspectual change can be modeled using hybrid logical BAFs, I will discuss what happens to (86a)'s term "$@_{act}\mathbf{write} \wedge \langle \textsc{Past}\rangle\langle \textsc{Prog}\rangle act$" in more detail. ⊛

Remark 8 (The imperfective paradox can be explained). Next to (85), consider (87).

(87) a. Elijah was wasting valuable time and money on becoming a John Wayne look-alike.

b. Elijah wasted valuable time and money on becoming a John Wayne look-alike.

The examples in (85) and (87) can be used to illustrate a phenomenon that Dowty (1979) called the *imperfective paradox* (cf. pp.133-135). The imperfective paradox intuitively comes down to the following problem. How can we account for the meaning of sentences like (85a) and (87a), such that (85a) may be true without (85b) ever necessarily becoming true, whereas (87a) would tautologically imply (87b)? Rephrased in terms of the event nucleus, the question whether (85a) $\Vdash$ (85b) means asking whether a preparation (necessarily) implies its completion in the event. Just as in (Blackburn et al., 1993), there is no contradiction in continuations of preparations to explicitly deny its culmination, (88).

(88) Christopher was writing a letter, but gave it up to play a game.

In a hybrid logical BAF the failure of a preparation e of sort act to culminate in a particular event e' of sort ach is represented by the fact that the *partial* function PREP is not defined onto e'.

This explains the relation between (85a) and (85b), but that is one part of the problem. The other part is, How does a hybrid logical BAF guarantee that (87a) $\Vdash$ (87b)? The ground for this guarantee is the requirement that $\forall e, i(i \sqsubseteq z(e) \leftrightarrow e\mathcal{Z}i)$. For any HL-BAF HB, and any interval i in HB, we have -per (83) and (84)- the following:

(89) $\mathsf{B}, i \Vdash \langle\textsc{Past}\rangle\langle\textsc{Prog}\rangle(\textit{Christopher's wasting ...})$
iff $\exists j(j < i \ \wedge \ \mathsf{B}, j \ \Vdash \ \langle\textsc{Prog}\rangle(\textit{Christopher's wasting ...}))$
iff $\exists j, e(j < i \ \wedge \ @_e(\textit{Christopher's wasting ...}) \ \& \ j \sqsubseteq {}^{+}z(e))$

But (89) means that $j \sqsubseteq z(e)$, and hence $e\mathcal{Z}j$. From this, we obtain (90).

(90) $\mathsf{B}, i \Vdash \langle\textsc{Past}\rangle(\textit{Christopher's wasting ...})$

In other words, we arrive at the conclusion that (87a) $\Vdash$ (87b), in a way similar to (Blackburn et al., 1993). ⊛

Remark 9 (Capturing aspectual change.). How do we use hybrid logical BAFs to capture aspectual change, as it is explained by Moens & Steedman's model? Here, I first focus on aspectual change brought about by the progressive (PROG) and the perfective (PERF) which I already discussed above. Then, I look at how we can model the aspectual change effectuated by particular dependency relations.

The aspectual changes that the progressive and the perfective may give rise to are modeled by the implications in (91), analogously to the modal rewriting rules that Oehrle (1999) employs in an account of binding.

(91) a. $\langle \textsc{Prog} \rangle (@_{act}\varphi \wedge @_{act}ref)$
$\rightarrow @_{act}\langle \textsc{Prog} \rangle progstate \wedge @_{progstate}\varphi \wedge @_{progstate}ref$

b. $\langle \textsc{Prog} \rangle (@_{acc}\varphi \wedge @_{acc}ref)$
$\rightarrow @_{acc}\langle \textsc{Prog} \rangle act \wedge @_{act}\varphi \wedge @_{act}ref$

c. $\langle \textsc{Perf} \rangle (@_{ach}\varphi \wedge @_{ach}ref)$
$\rightarrow @_{ach}\langle \textsc{Perf} \rangle constate \wedge @_{constate}\varphi \wedge @_{constate}ref$

Pictorally, what happens in e.g. (91a) is illustrated Figure 3.10. The lefthand side of the picture shows the normal framestructure of the event nucleus at the sorted eventuality structure O, and its reflection at the interval structure I as bounded intervals [..]. The righthand side displays the resulting structure: We now refer to a progressive state *progstate*, which is reflected by a non bounded interval [..).

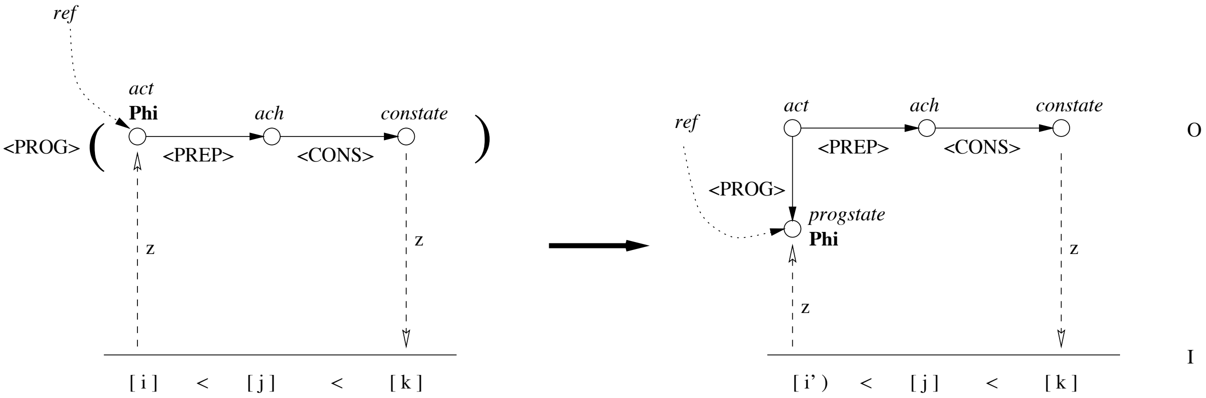

Figure 3.10: BAF visualization of PROG induced aspectual change

The contention here is that similar constructions can be given to represent other coercions - a topic I leave for future work, though. Instead, I would like to illustrate how we represent the effect that particular dependency relations have on aspectual change, as discussed earlier. Consider again (52), here repeated as (92). Our base case, the representation of "John walks", is given in (93).

(92) John walks $\begin{cases}\text{a mile.}\\ \text{to the park.}\end{cases}$ (Dowty, 1979)(p.60)

(93) $\mathcal{E} \wedge @_{act} ref \wedge @_{act}\mathbf{walk} \wedge @_{act}\langle\textsc{Actor}\rangle(j \wedge \mathbf{John})$

As Dowty (1979) points out, the aspectual category of "John walks" from being an activity to being an accomplishment, due to the modification by either a **Time:Till When** or **Direction:Where To** dependent. The resulting representation could then be as given e.g. in (94), with +ACHVMNT a modal relation to model the *+achievement* transition in Moens & Steedman's model.

(94) a. John walks [to the park $]_{WhereTo}$.

b. $\mathcal{E} \wedge @_{act}\langle +\textsc{Achvmnt}\rangle acc \wedge @_{acc} ref \wedge @_{acc}\mathbf{walk}$
$\wedge @_{acc}\langle\textsc{Actor}\rangle(j \wedge \mathbf{John}) \wedge @_{acc}\langle\textsc{WhereTo}\rangle(p \wedge \mathbf{park})$

However, applying any rule of the form as in (91a) would also have to result in reconsidering all bindings with the dependents, as the nominal refering to the state where the head holds, changes. To localize any aspectual change to the event nucleus proper, we can first of all consider the logical equivalent of (94b), given in (95).

(95) $\mathcal{E} \wedge @_{act}\langle +\textsc{Achvmnt}\rangle acc \wedge @_{acc} ref$
$\wedge @_{w} acc \wedge @_{w}\mathbf{walk}$
$\wedge @_{w}\langle\textsc{Actor}\rangle(j \wedge \mathbf{John}) \wedge @_{w}\langle\textsc{WhereTo}\rangle(p \wedge \mathbf{park})$

A formulation like (95) makes it possible to formulate rules for aspectual change effectuated by dependency relations, analogously to (91).

(96) a. $@_{h} act \wedge @_{h} ref \wedge @_{h}\langle\textsc{WhereTo}\rangle d$
$\rightarrow @_{act}\langle +\textsc{Achvmnt}\rangle acc \wedge @_{h} acc \wedge @_{h} ref \wedge @_{h}\langle\textsc{WhereTo}\rangle d$

b. $@_{h} act \wedge @_{h} ref \wedge @_{h}\langle\textsc{TillWhen}\rangle d$
$\rightarrow @_{act}\langle +\textsc{Achvmnt}\rangle acc \wedge @_{h} acc \wedge @_{h} ref \wedge @_{h}\langle\textsc{TillWhen}\rangle d$

c. $@_{h} act \wedge @_{h} ref \wedge @_{h}\langle\textsc{Locative}\rangle d$
$\rightarrow @_{act}\langle +\textsc{Achvmnt}\rangle acc \wedge @_{h} acc \wedge @_{h} ref \wedge @_{h}\langle\textsc{Locative}\rangle d$

d. $@_{h} act \wedge @_{h} ref \wedge @_{h}\langle\textsc{Result}\rangle d$
$\rightarrow @_{act}\langle\textsc{Inchoative}\rangle acc \wedge @_{h} ach \wedge @_{h} ref \wedge @_{h}\langle\textsc{Result}\rangle d$

e. $@_h act \ \wedge \ @_h ref \ \wedge \ @_h\langle\textsc{Counterfactual}\rangle d$
$\rightarrow \ @_{act}\langle\textsc{Inchoative}\rangle acc \wedge @_h ach \wedge @_h ref \wedge @_h\langle\textsc{Counterfactual}\rangle d$

To ensure that the hybrid logical representation of a sentence's linguistic meaning indeed comes to reflect the proper aspectual category, the rules in (91) and (96) are included in our logic as axioms. ⊛

3.4 DEPENDENCY RELATIONS

The aim of the current section is to describe the dependency relations that are distinguished in FGD (and which we use in DGL as well)[16]. The description relies in part on the discussions in Panevová's (1974; 1975), Sgall *et al.*'s (1986), and Petkevič's (1995; in prep). For each of the 38 dependency relations FGD distinguishes, I provide examples of forms in which the dependency relation can occur (usually, in various languages).[17] Most importantly, for each dependency relation I specify the *semantic import* it can have.[18]

By the 'semantic import' of a dependency relation I mean the following. When we interpret word forms, which occur in a sentence's outer form, either as heads or as dependents modifying those heads along specific relations, we are not just building a formal structure (that is, or is not, different from a structure developed on a constituency-based formalism). Particularly, by interpreting a word form as a dependent, we specify *how* the meaning underlying the word form contributes to the meaning of the head - and as such, to the linguistic meaning of the sentence. It is this 'how' that I mean when I speak of the semantic import of a dependency relation.

When I describe the semantic import of a dependency relation in this section, I make explicit use of the event nucleus discussed (and defined) in the preceding section. The event nucleus provides us with the essential information about temporal and causal structure, information that is

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[16] That is to say, FGD as discussed in Sgall *et al.*'s (1986), and Petkevič's (1995; in prep). Sgall *et al.* do remark that the list is not final. For example, see the longer list employed in tagging the Prague Dependency Treebank, documented in Hajičová *et al.* (2000).

[17] Important sources of inspiration for the examples given here are Panevová's (1975), Sgall *et al.*'s (1986), and Petkevič's (1995). If an example is taken straight from either of sources, proper citation is given.

[18] I should like to make clear though that the semantics I specify for the dependency relations are not claimed to exhaust all the possible interpretations of the dependency relations that FGD distinguishes.

augmented by the semantic import of dependency relations. The semantic import of a dependency relation is specified using hybrid logic and the hybrid logic-BAFs.

With every dependency relation being individually different, as pointed out earlier, we act here on the hypothesis that each dependency relation differs (among other things) in the characterization of its semantic import. At the same time, making the semantic import of each dependency relation more explicit, as we shall do here, also certain regularities across such characterizations come to light. These regularities give -quite naturally-rise to various *classes* of dependency relations.In particular, the classes of dependency relations I describe below are the following:

- Dependency relations relating eventualities in an "implicative" way.
- Dependency relations reflecting stage (time, direction, location).
- Dependency relations attributing qualities to objects.
- Dependency relations expressing modus operandi.
- Inner participants.

These classes are in part inspired by the intuitive grouping of dependency relations that Sgall *et al.* give in (1986) (pp.158-163).

3.4.1 DEPENDENCIES RELATING EVENTUALITIES IN AN IMPLICATIVE WAY

FGD distinguishes several dependency relations that indicate an "implicative" or "causal" relation between the eventuality to which the verbal head is related, and the eventuality to which the dependent can be related. Syntactically, a construction involving one of these dependency relations prototypically has a dependent that is itself a verbal head, or a noun derived from a verb (i.e. in both cases there is a clear reference to an eventuality).

The dependency relations that we consider to belong to this class are **Purpose**, **Cause**, **Result**, **Condition**, and **Concession**. All these dependency relations focus on one or another aspect of the causal structure of the event nucleus, as defined using GRiTo, Prep and Cons.

Purpose

The **Purpose** dependency relation signifies that obtaining the eventuality referred to by the dependent is the aim, or purpose, of the process denoted by the verb that is being modified by the dependent. For example,

(97) **English**
Christopher studies intensively [in order to pass the exam $]_{Purpose}$.

(98) **Dutch**

Elijah	heeft	hard	gespaard [	om	op	vakantie	te
Elijah	has been	diligently	saving	in order to	on	holidays	to

kunnen	gaan	$]_{Purpose}$.
be able	go	

"Elijah has been diligently saving in order to be able to go on holidays."

(99) **Czech**

Kryštof	intensivně	studuje,	aby	se	dostal	na
Christopher	intensively	studies	so that	REFL	admit	to

universitu.
university.

"Christopher studies intensively to be admitted to the university."

More specifically, I define the semantic import of **Purpose** as follows. The semantic import of **Purpose** assumes that the head is an *activity*.[19] The **Purpose** specifies an event nucleus to which the head's activity is a *preparation*. If we consider δ to be the event nucleus refered to by the **Purpose** dependent, and h the head (refering to an activity), then the semantic import can be defined as in (100).

(100) **Purpose**:
$@_h\langle\textsc{Purpose}\rangle\delta \rightarrow @_h\langle\textsc{Purpose}\rangle\delta \wedge @_h\langle\mathrm{F}\rangle\delta$,
"The process denoted by the verbal head makes it possible for the eventuality referred to by the dependent to obtain later."

---

[19] Oehrle (p.c.) remarks that it is perhaps better to consider the construction to be an "intentionally maintained state" rather than an activity. For example, it seems odd to express "I am here to further World Peace" with a progressive, in English. It needs to be considered whether (and if so, how) we need to refine Moens & Steedman's model to capture these more fine-grained distinctions.

Hence, reconsidering for example (97), we could phrase the semantic import of the **Purpose** relation as saying that

(101) (Chris studies intensively, "now") makes it possible that (Chris might pass the exam, "later on")

A point that can be raised against the characterization above is that it involves a dependent having a reference to an eventuality. But what about examples like (102-105)?

(102) **English**

The poor man begged for a few pennies.

(103) **Dutch**

De student vroeg om korting.
The student asked for discount

"The student asked for a discount."

(104) **Dutch**

Het kind hoopte op een groot kado.
The child hoped for a large present

"The child hoped for a large present."

In neither of these cases there is an explicitly mentioned verb. However, it seems reasonable to assume that with the meaning of the preposition it is specified that there is an implicit reference to *some relation*, here illustrated as an eventuality of obtaining - if we want to interpret the preposition as realizing the function of **Purpose**:

(105) **English**

The poor man begged for [obtaining] a few pennies.

(106) **Dutch**

De student vroeg om korting [te krijgen].
The student asked for discount [to obtain]

"The student asked for [obtaining] a discount."

(107) **Dutch**

Het kind hoopte op een groot kado [te krijgen].
The child hoped for a large present [to obtain]

"The child hoped for [obtaining] a large present."

Result

There exists an interesting contrast between **Purpose** and **Result**. For one, whereas **Purpose** indicates the *possibility* of an eventuality obtaining, a **Result** states the *necessity* of that eventuality obtaining. As Panevová notes (1974), that necessity can either be positive (the eventuality does obtain) or negative (the eventuality 'definitely' does not obtain). This can be modeled using negation of the proposition holding at the state refered to by a **Result** dependent.

Another interesting aspect of **Result**, closely related to the mentioned necessity, is that it assumes the head to be of a different aspectual category than **Purpose** does. Namely, a **Result** assumes the head to be an aspectual category that has an identifiable culmination point - thus, either an achievement or an accomplishment. For simplicity, I define the semantic import of **Result** using achievement only.[20] Then, because a result lacks any definite temporal bounds, it can be identified with a state - particularly, a **Result** specifies the consequent state of the head's event nucleus.

(108) **Result**:
$\mathcal{E} \wedge @_h\langle \textsc{Result}\rangle\delta \rightarrow \mathcal{E} \wedge @_{consequent}\delta \wedge @_h[\mathrm{F}]\delta \wedge @_h\langle \textsc{Result}\rangle\delta$
"The process denoted by the verbal head makes it necessary for the eventuality refered to by the dependent to obtain ("as a result of that")."

(109) **English**
Elijah lowered the fire [so that the meat would not burn $]_{Result}$.

(110) **English**
Kathy opened the door [in order to let Christopher in $]_{Result}$.

Cause

Both in the case of **Purpose** and in that of **Result** the eventuality referred to by the dependent is assumed to occur after it. **Cause** presents the opposite case, as it were. Namely, the eventuality refered to by the head is

---

[20] There is a deeper reason here than a mere desire for simplicity: It seems to me that if we take an accomplishment, then what we would *actually* take is a composite event consisting of an achievement with an active component ("+activity"), whereby the *composite* is indeed an achievement due to type coercion. Empirical data would hopefully shed more on this.

implied by the one referred to by the dependent - and, from a temporal perspective, necessarily so.[21] Consider for example the following sentences.

(111) **English**
The road was blocked [because the river had crossed its banks]$_{Cause}$.

(112) **English**
Christopher's salad tasted horrible [because he had forgotten to add olive oil]$_{Cause}$.

(113) **English**
The dinner party was saved [owing to Kathy having prepared a splendid dessert]$_{Cause}$.

However, we can also have sentences of the like of (114-117).

(114) **Dutch**

De berekening leverde een foute uitkomst op [vanwege een
The calculating provided a wrong result due to an
fout in het programma]$_{Cause}$.
error in the program

"The calculation provided a wrong result due to an error in the program."

(115) **English**
The train halted [because of a sheep on the tracks]$_{Cause}$.

(116) **English**
The road was blocked [due to an accident]$_{Cause}$.

(117) **English**
The road was blocked [because of a flooding]$_{Cause}$.

The situation here is not much different from before, cf. examples (102-105) on page 73. Leaving those nouns aside that are derived from verbs (and thus are assumed to already refer to an eventuality; example 117), we still have constructions like (114-116). Again it seems reasonable to assume, as I did before, that there is an implicit 'verb' introducing a reference to an eventuality:

---

[21] This characterization should be understood as a simplification. I do not have here the possibility to systematically inquire into the often discussed issue of what is the proper meaning of 'cause'. Therefore, I present here only a characterization of **Cause** as a condition having a necessary consequence, refered to by the governing clause.

(118) **English**
The road was blocked [due to [there being] an accident $]_{Cause}$.

(119) **English**
The train halted [because of [there being] a sheep on the tracks $]_{Cause}$.

For illustration we used "there being" but one could also think of "there having occurred", etc. The point is not what 'verb' we should consider to have been 'deleted' - the issue here is *not* deletion, the issue is that there is an implicit reference to an eventuality. Like we proposed in the case of the English *for* and the Dutch *om*, if the preposition combines with a noun that is not derived from a verb, and the form (i.e. the prepositional group) is to be interpreted as realizing the function of a **Cause**, then we can assume a reference to an eventuality to be part of its meaning.

This leads us then to the characterization of **Cause**, as in (120). I assume the **Cause** to be an activity, relating on the head's preparatory activity.

(120) **Cause**:
$\mathcal{E} \wedge @_h\langle\textsc{Cause}\rangle\delta \rightarrow \mathcal{E} \wedge @_\delta act \wedge @_\delta[\mathrm{F}]h$
"The eventuality referred to by the verbal head was caused by the process referred to by the dependent, which happened before the eventuality referred to by the verbal head."

Figure 3.11 visualizes the relations induced by a **Cause**, both at the level of O and at I. To elucidate how the idea of *causality* is incorporated in a definition like (120), it is instructive to recall Definition 9 at this point. There, I defined hybrid logical BAFs, and -among others- the `GRiTo` ("Gives Rise To") function. `GRiTo` defines the behavior of the modal operators Prep and Cons, which provide the causal structure of Moens & Steedman's event nucleus. Now it is easy to see how a causal relationship between a **Cause** dependent and the head is established: We equate δ with *act*, and thus bring it into a Prep relation with the head. (In other words, we make essential use of the causal nature of event nucleus.)

Finally, consider (121), as an illustration of **Cause** as a free modifier allowing for multiple occurrences.

(121) **English**
[Due to poverty $]_{Cause}$ many people died [of TBC $]_{Cause}$, [since its

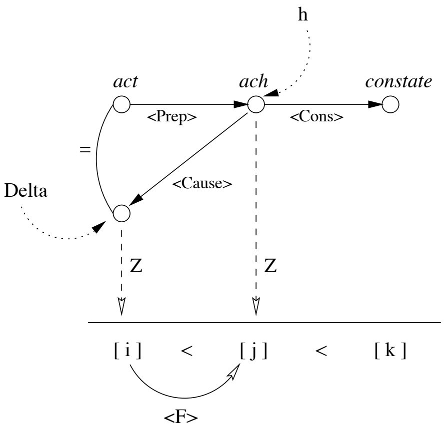

Figure 3.11: BAF visualization of CAUSE's semantic import

treatment was expensive $]_{Cause}$.
(Panevová, 1994),p.228

Condition

The dependency relation **Condition** is related to **Cause** in that it assumes a similar implication between the eventuality refered to by the head, and that refered to by the dependent. In the context of this dissertation, I make the simplifying assumption that **Condition** differs from **Cause** in its temporal reference - that is to say, the time frame it concerns. Whereas with **Cause** I understand the eventualities to have occurred (or at least started) before the time the sentence was uttered, a **Condition** is taken here to involve a future reference.[22]

The exact form that such 'future reference' takes depends on the type of condition. Various authors have distinguished -at least- two types of conditions. Here, I consider **Factual** and **Counterfactual**, (because of their inclusion in the list of dependency relations presented in (Petkevič, 1995)). With the **Factual**, we might understand the 'future reference' to refer to a point in the future relative to the here and now when the sentence is being uttered:

(122) **English**
Elijah will not be able to go skiing [if Kathy does not financially

---

[22] Note that *indicative conditionals* form an exception to this: "If Christopher is at the met now, then he arrived in New York last night."

support him $]_{Factual}$.

(123) **English**
[In hot weather $]_{Condition}$ the number of patients rises very quickly,
[if medical assistance is not substantially increased $]_{Condition}$.
(Panevová, 1994), p.228

The **Counterfactual** is based at a point in the past relative to the eventuality to whose future the **Counterfactual** refers. That future can possibly be in the past relative to the here and now as (124) illustrates, but this is not necessarily so.

(124) **English**
[If Christopher had known the project would be so time-consuming $]_{Counterfactual}$, he would never have started working on it.

For **Factual** and **Counterfactual** I propose the following, preliminary characterizations:[23]

(125) **Factual**:
$@_h\langle\textsc{Factual}\rangle\delta \;\rightarrow\; @_h\langle\textsc{Factual}\rangle\delta \;\wedge\; @_h[\mathrm{P}]\delta$
"For the eventuality refered to by the head to obtain, it is necessary that first of all the eventuality refered to by the dependent obtains."

(126) **Counterfactual**:
$@_h\langle\textsc{Counterfactual}\rangle\delta \;\rightarrow\; @_h\langle\textsc{Counterfactual}\rangle\delta \;\wedge\; \neg @_\delta\langle\mathrm{F}\rangle h$
"It necessarily follows from the eventuality refered to by the dependent that the eventuality refered to by the head cannot obtain."

Again, the definitions employ in an essential way the causal aspects of the event nucleus. For example, consider the definition for the **Counterfactual**, (126). There, it is stated that δ has no possible future relating it to h - a relation at the level of intervals, I. By 'completing the square', it follows that δ cannot be in either a PREP or a CONS relation to h, at the level of eventuality occurrences O. Thus, h cannot be brought about by the **Counterfactual** δ.

---

[23] Again, it is important to bear in mind that at this point the aim is to develop an intuitive feel for what the various dependency relations might mean. Characterizations like (125) and in particular (126) are not intended to do full justice to the logical interpretation factual and counterfactual statements might have, as discussed in the literature. Carpenter provides a brief review in (1997).

Concession

The final dependency relation we consider under the heading of dependency relations that reflect an implicative relation between the verbal head and its dependent, is **Concession**. That there is a notion of implication involved is illustrated for example by Halliday's characterization in (1985) of concession as conveying "if P then, contrary to expectation, Q." The next couple of examples instantiate this view:

(127) **English**
[Although the traffic lights showed red $]_{Concession}$, Kathy recklessly drove on.

(128) **Dutch**

[Alhoewel Elijah anders een goede smaak heeft $]_{Concession}$,
Although Elijah otherwise a good taste has ,
kon Kathy zijn onlangs aangeschafte rood-leren cowboy laarzen
could Kathy his recently acquired red-leather cowboy boots
niet waarderen.
not appreciate

"Although Elijah has otherwise got a good taste, Kathy could not appreciate his recently acquired red-leather cowboy boots."

(129) **English**
Although Christopher carried his dog in the underground, he got a fine.

Implicit in all these examples is that the **Concession**-dependent invokes an expectation, which takes the form of an implication, the consequent of which then gets negated by the clause of the verbal head. Or, to use the causal structure of the event nucleus, the preparation did not lead to the expected event, but rather to the opposite.

(130) **Concession**:

$$\mathcal{E}_h \wedge @_h\langle\textsc{Concession}\rangle\delta \wedge \mathcal{E}_\delta \rightarrow$$
$$\mathcal{E}_h \wedge @_h\langle\textsc{Concession}\rangle\delta \wedge \mathcal{E}_\delta \wedge @_\delta\langle\textsc{Prep}\rangle ach_\delta \wedge @_{ach_\delta}\varphi$$
$$\wedge\ @_\delta\langle\textsc{Prep}\rangle ach_h \wedge @_{ach_h}\neg\varphi$$

"Whereas it was possible ("expected") that φ would obtain given the process denoted by the dependent, the opposite actually occurred."

Constructions realizing a **Concession** mostly involve what Knott (1996) calls "negative polarity causal connectives", like the English *although*, *however*, *nevertheless*. Kruijff-Korbayová and Webber discuss in their (2000; 2001) how one can give a more detailed account of the semantics of these connectives, making use of Knott's work and of Lagerwerf's (1998).

The characterization of **Concession** I give in (130) leaves open a number of issues that Kruijff-Korbayová and Webber do address - notably, the exact status of expectations, when thought of as defeasible rules that are being presupposed by a negative polarity causal connective. The main idea expressed here is that aspect plays an important role also in concessions, as they relate to the causal structure of an event nucleus. Naturally we could try to *accommodate* the more precise causal relation(s) that Kruijff-Korbayová and Webber discuss. One way in which this could conceivably be done would be to refine the model-theoretic semantics of `GRiTo` (and, more specifically, Prep), such that the relation would display a model-theoretic behavior mimicking a defeasible implication. Figure 3.12 shows the relations that hold between the event nuclei that the head and the dependent relate to, and illustrates the above point regarding `GRiTo`.

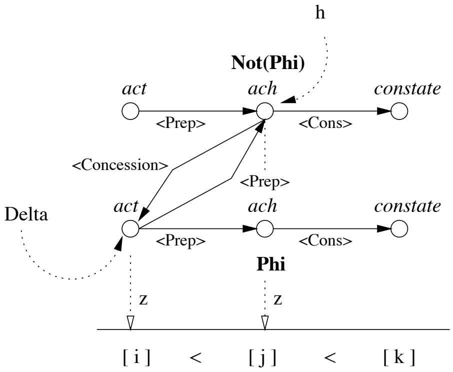

Figure 3.12: BAF visualization of CONCESSION's semantic import

3.4.2 Dependencies signifying time, direction, or location

A fairly large number of dependency relations signify a temporal aspect of the process that the verbal head signifies, or a direction or location. All these dependency relations are gathered here under the common denominator "stage dependencies", as they can be thought of as 'setting the stage'.

Time

The **Time:Since When** dependency relation indicates that the head's eventuality covers an interval of time which started at the time of the dependent's eventuality. Making use of the $\langle\textsc{Since}\rangle$ modal operator (cf. (Blackburn, 1990)) we can define **Time:Since When** as in (131).

(131) **Time:Since When**: for e the eventuality of the head, and τ the temporal nominal expressed by the dependent, $@^{I}{}_{e}\langle\textsc{Since}\rangle\tau$. Or, if the dependent refers to an eventuality, then we have that
$@_e\langle\textsc{Since When}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \rightarrow$
$@_e\langle\textsc{Since When}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \wedge \ @^{I}{}_{e}\langle\textsc{Since}\rangle\tau$

In English, constructions involving **Time:Since When** often use prepositional groups formed with *from* or *since*, as illustrated in (132-134) below.

(132) **English**
Kathy has been working [since last night $]_{Since}$.

(133) **English**
Charles University has been in existence [from the 14th century on $]_{Since}$.

(134) **English**
Christopher and Elijah know each other [from the time they were at basic school together $]_{Since}$.

The **Time:Till When** dependency relation is in a sense the opposite of **Time:Since When**. Whereas **Time:Since When** indicates a starting point, the dependent modifying a head by **Time:Till When** marks the ending point of the verbal head's eventuality[24]. In keeping with that observation, I use $\langle\textsc{Until}\rangle$ rather than $\langle\textsc{Since}\rangle$ to define **Time:Till When**.

(135) **Time:Till When**: for e the event of the head, and τ the temporal nominal expressed by the dependent, $@^{I}e\langle\textsc{Until}\rangle\tau$. Or, if the dependent refers to an eventuality, then we have that
$@_e\langle\textsc{Until When}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \rightarrow$
$@_e\langle\textsc{Until When}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \wedge \ @^{I}{}_{e}\langle\textsc{Until}\rangle\tau$

---

[24] Or, if present tense is used, and it is clear from the context that the speaker means to be talking about the here and now, then the dependent can be taken to indicate that the process signified by the verb has lasted -at least- until the very moment the sentence was uttered - see example (137).

(136) **English**
Christopher was in New York [till yesterday $]_{Till\ When}$.

(137) **English**
Kathy has not been able to find a solution [until now $]_{Till\ When}$.

A dependent modifying a verbal head along **Time:When** identifies the time of the head's eventuality.

(138) **Time:When**: for e the event of the head, and τ the temporal nominal expressed by the dependent, $@^{I}e\tau$. Or, if the dependent refers to an eventuality, then we have that $@_{e}\langle\textsc{When}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \rightarrow$ $@_{e}\langle\textsc{When}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \wedge \ @^{I}{}_{e}\tau$.

Again, as the following examples make clear, we need not be thinking about a concrete time-*point*: the dependent may well indicate an *interval.* The crux is that dependent refers to a more or less identifiable timing (i.e. a time point or an interval, thebounderies of which in the general case are indistinct). Examples (139) and (140) identify intervals, whereas (141) marks a specific time point.

(139) **English**
Christopher visited the *Barnes & Nobles* on Broadway [the day before yesterday $]_{When}$.

(140) **English**
Kathy finished her book [before going to sleep $]_{When}$.

(141) **English**
The server crashed exactly at [punctually 6 o'clock in the evening $]_{When}$.

Aspect and tense naturally can play an important role here, as discussed for example by Steedman (2000b). Similarly, Panevová (p.c.) cites examples as in (142) through (145).

(142) **Czech**

Když	maminka	vstoupila	do	místností,	tatínek
When	entered-PERF	mom	into	room,	daddy
rozsvítil.					
turn-on-light-PERF					

“When mom entered the room, daddy turned on the light.”

(143) **Czech**

Když maminka vstupovala do místností, tatínek
When entered-IMPERF mom into room, daddy
rozsvěcoval.
turn-on-light-IMPERF

“When mom was entering the room, daddy was turning on the light.”

(144) **Czech**

Když maminka vstupovala do místností, tatínek
When entered-IMPERF mom into room, daddy
rozsvítil.
turn-on-light-PERF

“When mom was entering the room, daddy turned on the light.”

(145) **Czech**

Než maminka vstoupila do místností, tatínek
Before mom entered-PERF into room, daddy
rozsvítil.
turned-on-light-PERF.

“Before mom entered the room, daddy turned on the light.”

The understanding is that (142) can be paraphrased using “after”, thus indicating that the temporal extent indicated by the dependent occurs in the future of that of the event of the modified head. (143) on the other hand illustrates a dependent that specifies a temporal extent occurring *during* that of the modified head, with the change in aspect in (143) indicating (only) a partial *overlap*. Panevová’s last example, (145), illustrates strict temporal precedence (i.e. no overlap). All these dependents would be analyzed as **Time:When** dependents in FGD, though, since the quoted differences are expressed by those of the conjunction and by aspect, in Czech, rather than by tense (Sgall & Hajičová, p.c.).

Formally, to cover examples like (142) through (145), we need to couple the definition of e.g. the perfective Perf (83) or an imperfective counterpart Imperf to the definition of e.g. **Time:When** (138), and consider their interaction. For example, the perfective with the semantic import of **Time:When** identify a past interval. If we combine this with the perfective of the main clause, as in (145), and an -intuitive- interpretation of “before” as temporal precedence ($<$), then we adequately cover the intended meaning of (145).

Time:How Long identifies a period of duration.

(146) **Time:How Long**: for e the event of the head, and τ the temporal nominal expressed by the dependent, $@^{I}e\tau$ (with τ of an interval sort).

(147) **English**
Elijah stayed in Texas [through the entire winter $]_{How\ Long}$.

(148) **English**
The *Muppet Show* was broadcast on Dutch TV [during the 1970’s and 1980’s $]_{How\ Long}$.

Sgall *et al.* briefly point out in (1986), a **Time:For How Long** describes an *intended period* (p. 159), as in (149) below:

(149) **English**
He will work on this topic [for his whole life. $]_{For\ How\ Long}$

Here, I define the semantic import of **Time:For How Long** as identical to that of **Time:How Long**, leaving the inference of any possible intentions behind **Time:For How Long** to the stage of discourse interpretation.

The **Time:Contemporariness** dependency relation elucidates that the dependent’s eventuality overlaps with the verbal head’s eventuality. Syntactically, the dependent is either a verb (150), or a noun derived from a verb (151). Both are assumed to have meanings with an identifiable temporal extent (at I).

(150) **English**
Christopher fell asleep while the potatoes were boiling.

(151) **English**
Christopher slept during his flight from New York.

(152) **Time:Contemporariness**:

$$@_{h}\langle\textsc{Contemp}\rangle\delta \ \wedge \ @^{I}{}_{\delta}\tau \ \wedge \ @^{I}{}_{h}\tau' \ \rightarrow$$
$$@_{h}\langle\textsc{Contemp}\rangle\delta \wedge @^{I}{}_{\delta}\tau \wedge @^{I}{}_{h}\tau' \wedge (@_{\tau}\langle\textsc{During}\rangle\tau' \vee @_{\tau'}\langle\textsc{During}\rangle\tau)$$

Directions and Locative

FGD distinguishes one dependency relation specifying the location of the head (**Locative**), and various types of dependency relations designating direction (**Direction:From Where**, **Direction:Through**, **Direction:Where To**). We can conceive of each of these dependency relations as determining a location relative to the eventuality referred to by the head that is being modified.

To be able to capture this, the hybrid logical BAFs capturing causal and temporal information need to be extended to cover also *locations*. Intuitively, eventualities are not just causally related at O and have a temporal extent reflected at I, but they also have a *spatial* extent. Again, the sorting strategy of hybrid logic provides interesting possibilities. Here, I propose to start with two sorts of spatial extent ("locations"): *points*, and *areas*.[25] Definition 10 makes these ideas more precise.

Definition 10 (Adding spatial extent to HyLo-BAFs). *We define a* sorted spatial structure*,* S_s*, as a tuple* $\mathsf{S}_s = \langle \mathfrak{S}, \textit{\textbf{Conn}}, \textsc{Move}, \textsc{Incl}, P_s \rangle$. $\mathfrak{S}$ *is a set of spatial nominals, composed from two disjoint sets* $\mathcal{P}$ *(points) and* $\mathcal{A}$ *(areas).* $\textit{\textbf{Conn}}$ *is a function that defines whether two spatial extents are connected.* $\textsc{Move}$ *and* $\textsc{Incl}$ *are modal operators for which it holds that* $\textsc{Move} \subset \textit{\textbf{Conn}}$ *and* $\textsc{Move} \subset \textit{\textbf{Conn}}$*.* $\textsc{Move}$ *is a partial function on spatial nominals, defining whether one can move from one place to another.* $\textsc{Incl}$ *is also a partial function on spatial nominals, defining spatial inclusion.*

To relate S_s *to* I_s *and* O_s*, we define two relations,* l *and* $\mathcal{L}$*.* l *is a function that determines the spatial extent of an eventuality occurrence at a particular time. It is defined as a morphism from* $\mathfrak{E} \times \mathfrak{I}$ *to* S_s*. Similar to* $\mathcal{Z}$ *we define a relation* $\mathcal{L}$*.* $\mathcal{L}$ *ensures* downward spatial connectedness*: If we take a subinterval of a* $\mathfrak{E} \times \mathfrak{I}$ *tuple, then we obtain a spatial extent that is (reflexively, transitively) connected to a spatial extent of another subinterval of that tuple.*[26] *Finally, an additional "bi-sortal" jump-operator is defined to state that an eventuality* ϵ *occurs at a particular place* π*, at a particular time* i *in* I*:* $@^{i/S}{}_{\epsilon}\pi$*, i.e.* $i = z(e)\ \&\ l(i,e) = s \ \Rightarrow\ @_s\pi$*.*

A hybrid logical BAF with spatial extension is defined here as a tuple

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[25] Without further discussion about spatial ontology, I understand them as the spatial analogues of temporal points and intervals.

[26] Essentially, this means that if an eventuality involves a movement through time, that movement goes along connected places.

$\mathit{HB}{=}\langle \mathsf{O}_s, z, \mathcal{Z}, \mathsf{I}_s, \mathsf{S}_s, l, \mathcal{L}\rangle$, *with* $\mathsf{O}_s, z, \mathcal{Z}, \mathsf{I}_s$ *as defined in Definition 9.*⊛

A **Direction:Where To** dependent identifies the location to which we are able to make a move from the head's eventuality's current location:

(153) **English**
Christopher intends to go [to Amarillo, Texas $]_{\mathit{Where-To}}$.

(154) **English**
Elijah rather wanted to go [to Big Springs, Texas $]_{\mathit{Where-To}}$.

Direction:From Where similarly identifies a location relative to the head's eventuality, from where the process signified by the head has its origin:

(155) **English**
Christopher arrived [to Dallas $]_{\mathit{Where-To}}$ [from New York $]_{\mathit{Where-From}}$.

(156) **English**
Kathy will leave [from Prague $]_{\mathit{Where-From}}$ to go [to Rio $]_{\mathit{Where-To}}$.

Whereas **Direction:Where To** identifies an 'end point' and **Direction:From Where** a 'starting point', **Direction:Through** specifies a location that is neither the starting point nor the end point. Depending on the tense of the verbal head, the dependent either determines a location that was visited in the past before reaching the current location (157), or a location that will be visited in the future (158):

(157) **English**
Christopher drove [through Big Springs $]_{\mathit{Through}}$ on his way to Amarillo.

(158) **English**
Kathy will fly [via Schiphol $]_{\mathit{Through}}$ when going to Rio.

Finally, **Locative** specifies the location of the head's eventuality:

(159) **English**
[In Amarillo $]_{\mathit{Locative}}$, Christopher and Elijah met [at the local *Starbucks* coffee shop $]_{\mathit{Locative}}$.

To formulate the semantic import of these dependency relations, I employ the extended hybrid logical BAFs provided in Definition 10.

(160) **Locative**:

$$@_h\langle\textsc{Locative}\rangle\delta \;\rightarrow\; @_h\langle\textsc{Locative}\rangle\delta \;\wedge\; @^{I}{}_{h}\tau \;\wedge\; @^{\tau/S}{}_{h}\delta$$

(161) **Direction:Where To**:

$$@_h\langle\textsc{WhereTo}\rangle\delta \;\rightarrow$$
$$@_h\langle\textsc{WhereTo}\rangle\delta \;\wedge\; @^{I}{}_{h}\tau \;\wedge\; @^{\tau/S}{}_{h}\delta' \;\wedge @_{\delta'}\langle\textsc{Move}\rangle\delta$$

(162) **Direction:From Where**:

$$@_h\langle\textsc{WhereFrom}\rangle\delta \;\rightarrow$$
$$@_h\langle\textsc{WhereFrom}\rangle\delta \;\wedge\; @^{I}{}_{h}\tau \;\wedge\; @^{\tau/S}{}_{h}\delta' \;\wedge @_{\delta}\langle\textsc{Move}\rangle\delta'$$

(163) **Direction:Through**:

$$@_h\langle\textsc{Through}\rangle\delta \;\rightarrow$$
$$@_h\langle\textsc{Through}\rangle\delta \wedge @^{I}{}_{h}\tau \wedge @_{\tau'}\langle\textsc{During}\rangle\tau \wedge @^{\tau'/S}{}_{h}\delta \wedge @^{\tau/S}{}_{h}\delta' \wedge @_{\delta'}\langle\textsc{Incl}\rangle\delta$$

3.4.3 ATTRIBUTIVE DEPENDENCY RELATIONS

Attributive dependency relations are those dependency relations that can modify nouns, attributing particular characteristics to the head noun. The fact that these dependency relations modify nouns, and not verbs (or adjectives) makes them different from the manner-like dependency relations we will discuss below.

Modifications of nouns, and the idea of valency frames for nouns, has been explored in Praguian linguistics for example by Pitˇha (1980; 1981) - see also (Sgall et al., 1986) p.161ff and (Panevová, 1994). Pitˇha describes how some of the dependency relations distinguished primarily for modifying verbal heads can also occur in valency frames for nouns. On the other hand, the following dependency relations typically modify nominal heads only: **Partitive**, **Appurtenance**, **Identity**, **General Relationship**, and **Descriptive Property**.

The **Partitive** dependency relation expresses measured units (164) or a measured abstract notion (165):[27]

(164) **English**
Christopher brought Kathy a bunch [of flowers]$_{Partitive}$ for her valiant behavior.

---

[27] One does find the **Partitive** defined in terms of "measured *material*", cf. e.g. (Petkevič, 1995) - which seems a bit of an awkward way to talk about, for example, 'a group of children'.

(165) **English**
Elijah was full [of hope $]_{Partitive}$ that people would like his red-leather cowboy boots.

An **Appurtenance** dependent describes an integral part of the meaning of the nominal head that it modifies. There are nouns that are considered to have a valency frame in which **Appurtenance** occurs as obligatory. Sgall *et al.* mention in (1986) nouns like “brother”, “beginning”, and “surface” - since, for example, a brother is always referred to as a brother *of someone*, and similarly for the beginning or surface *of something*, etcetera:[28]

(166) **English**
Christopher is [Elijah’s $]_{Appurtenance}$ brother.

(167) **English**
Kathy inadvertedly hit the leg [of the table $]_{Appurtenance}$.

The other three dependency relations, namely **General Relationship**, **Identity**, and **Descriptive Property**, attribute characteristics to the meaning of the nominal head that are either *restrictive* (**General Relationship**) or *unrestrictive* (**Identity**, **Descriptive Property**). A **General Relationship** is restrictive in the sense that it narrows what Petkevič calls the “semantic extent” of the nominal head (cf. also (Sgall et al., 1986), pp 161-162 and the reference therein to work by Koktová):

(168) **English**
Elijah really treasures a [half-eaten $]_{GenRel}$ [*BIC* $]_{GenRel}$ pen.

(169) **English**
Fortunately, Elijah only bought [one $]_{GenRel}$ pair of red-leather cowboy boots.

On the other hand, neither **Identity** nor **Descriptive Property** are understood to be restrictive, like in (170) and (171) respectively:

(170) **English**
Both Christopher and Elijah have visited the city
[of New York $]_{identity}$.

---

[28] Observe how we can again apply the dialogue test to find out whether a complement is obligatory or not - it seems hard to conceive that one could call a person to be a brother (i.e. a member of a family) without knowing whose brother that person would be.

(171) **English**
However, they prefer [Golden $]_{Descr.Prop}$ Prague or [sweet $]_{Descr.Prop}$ France over the Big Apple. (After (Petkevič, 1995))

The differentiation of **General Relationship** and **Descriptive Property** can be related to the distinction *restrictive* and *attributive* readings, respectively.

In formal semantics, an attributive reading is understood as specifying an additional property of a referent which is already sufficiently identified by the head noun. A restrictive reading, on the other hand, specifies a property which further restricticts the (set of) possible referent(s).The extent to which we can understand the differentiation of **General Relationship** and **Descriptive Property** as similar to this semantic distinction is as follows. As Sgall *et al.* (1986)(§2.42) point out, **General Relationship** and **Descriptive Property** can have different surface realizations. Thus, a speaker can choose to *present* an adjective as either attributive or restrictive, (just as a speaker can choose to *present* something as contextually bound or nonbound). It is then left to the later stage of discourse interpretation to see whether an attributive or restrictive reading indeed leads to a possible coherent linguistic meaning, on the basis of accessible referents. At the level of linguistic meaning we do not resolve that issue, leaving it -in a sense- underspecified.[29]

With the above in mind, we could give the following, preliminary specification of the semantic import of **Descriptive Property** (172).

(172) **Descriptive Property**:
$@_h\langle\rho\rangle\delta \ \wedge \ @_\delta\langle \textsc{DescrProp}\rangle\pi \ \rightarrow$
$@_h\langle\rho\rangle\delta \ \wedge \ @_\delta\langle \textsc{DescrProp}\rangle\pi \ @_h\langle \text{XS}\rangle\delta \ \wedge \ @_h[\text{XS}]\delta$

---

[29] The orthogonal issue of intersective/non-intersective readings is left entirely to the stage of discourse interpretation. Because we do not use a predicate logic here but a modal logic, we always have a relational structure: both $ball(x) \wedge red(x)$ and $skillful(writer(x))$ are presented in the form $head \wedge \langle\textsc{relation}\rangle dependent$. Instead of imposing different logical structures to reflect (non-)intersectivity, the "responsibility" is moved to the lexicon: It is with the meaning of e.g. the adjective that we would have to specify whether it leads to an intersective reading, or a nonintersective one. For the sake of illustration, assume that the lexical meaning of a nonintersective adjective would lead -in a concrete case- to the following specification of a **Descriptive Property** modification: $@_h\langle\textsc{DescrProp}\rangle(\delta \ \wedge \ @_\delta\langle\textsc{NonIntersect}\rangle h)$. Then, the following axiom could provide a preliminary formulation of the intuition that the same property δ is not attributed to some other head h' as well: $@_h\langle\textsc{DescrProp}\rangle(\delta \ \wedge @_\delta\langle\textsc{NonIntersect}\rangle h) \ \rightarrow \ @_h\langle\textsc{DescrProp}\rangle(\delta \ \wedge \ @_\delta\langle\textsc{NonIntersect}\rangle h) \ \wedge \ \neg(@_{h'}\langle\textsc{DescrProp}\rangle\delta \ \wedge \ \neg @_{h'}h)$, "for a suitable h'."

3.4.4 DEPENDENCY RELATIONS OF MANNER - MODUS OPERANDI

In (1986), Sgall *et al.* discuss various classes of dependency relations, among which they distinguish a class of dependency relations regarding manner, and a class of dependency relations closely related to manner (p.160):

1. "modifications of **Manner** and a few other, similar ones, such as **Regard**, **Extent** [...], **Norm** [...], **Criterion** [...], **Substitution** [...], and **Accompaniment**"
2. "other free modifications that are close to **Manner** [...]. These modifications comprise **Means**[...], **Difference**, [**Beneficiary**], and **Comparison**"

Here, we consider a slightly different division. Abstractly, we will group most of the above relations into a general class of *modus operandi* dependency relations (except for **Beneficiary**). Within that class, a further distinction is made between dependency relations that express modus operandi relatively, like a **Norm** describes the manner in which the process denoted by the verbal head happens relative to an (external) standard, or dependency relations that describe the manner more "intrinsically", like **Manner** or **Extent**.

Relational modus operandi

By "relational modus operandi" we understand those dependency relations that describe the way in which the process denoted by the verbal head happens, by relating it to an external event or object. Prototypical examples are **Norm** and **Criterion**, or Koktová's **Attitude** that we understand here to give a qualification of a process by relating it to the speaker's attitude towards it. The other dependency relations we consider in this class are **Restriction**, **Accompaniment**, **Substitution**, **Regard**, and **Difference**.

The **Norm** dependency relation expresses that the process denoted by the verbal head happens in accordance with an established standard (173) or expectation (174):

(173) **English**
Kathy drives [in accordance with the traffic rules. $]_{Norm}$

(174) **English**
The experiment went [as we had expected it to go $]_{Norm}$.

A dependency relation that is similar to **Norm** is **Criterion**: Whereas **Norm** expresses that something happens *in accordance with*, a **Criterion** describes that something happens or should happen according to the information of someone. Thus, whereas **Norm** is *descriptive*, we understand **Criterion** to be *prescriptive* - which obviously has a different semantic import. For example, compare (175) to (173) above:

(175) **English**
[According to traffic law $]_{Criterion}$, you are not allowed to drive when under influence of alcohol.

Example (173) expresses that Kathy drives in accordance with the traffic rules, and that that is so (at least for the period covered) - there is no exception to be derived from that. Example (175) establishes a more *defeasible* connection - even though one is not allowed to drive when drunk, that still does not mean it does not happen that people do drive shortly after having consumed alcohol.

Among the other dependency relations in this class are **Substitution** (176), **Means** (177-178), **Accompaniment** (179,180). For **Accompaniment** we can distinguish a positive and negative version.

(176) **English**
Kathy was appointed chair of the party committee [instead of Elijah $]_{Subst.}$.

(177) **English**
Elijah prefers to write [with a half-eaten *BIC* pen $]_{Means+}$.

(178) **English**
Christopher arrived [by bike $]_{Means+}$.

(179) **English**
In the park, Christopher likes to walk [with his dog $]_{Accomp+}$ and whistle.

(180) **English**
Despite the freezing wind, Christopher went out [without a coat $]_{Accomp-}$.

Also in the case of the **Regard** dependency relation, positive and negative versions can be distinguished:

(181) **English**
[As for his figure $]_{Regard+}$, Elijah is a tall guy.

(182) **English**
Christopher is very sensitive [with regard to his sun tan $]_{Regard+}$.

(183) **English**
Kathy crossed the busy street [regardless of the possibilty of causing a serious accident $]_{Regard-}$.

In FGD a distinction is also made between dependency relations **Comparison** and **Difference** (Sgall et al., 1986). **Comparison** is the complementation in examples such as "faster than X" or "as fast as X" (Sgall et al., 1986)(p.160,199) whereas a **Difference** is "a complementation of verbs and adjectives with the comparative degree of comparison" (Petkevič, 1995).

(184) **English**
Christopher is [two inches $]_{Differ.}$ taller than Elijah. (Sgall et al., 1986)

(185) **English**
Elijah's cowboy boots are [as red as $]_{Compar.}$ herrings.

(186) **English**
Elijah is [faster than Christopher $]_{Compar.}$. (Sgall et al., 1986)

Finally, we consider **Attitude** to be a member of this class of dependency relations. The **Attitude** dependency relation expresses the attitude, either of the *speaker* (187) or of a person explicitly mentioned (188):

(187) **English**
Elijah is [probably $]_{Attitude}$ small.

(188) **English**
Christopher thinks that Elijah is [probably $]_{Attitude}$ small.

"Intrinsic" modus operandi

Under the heading of "intrinsic" modus operandi we consider the **Manner** and **Extent** dependency relations. These dependency relations might be understood to express a characteristic of a process that regards the way in which it is performed.

(189) **English**
Kathy is doing [well]$_{Manner}$. (Sgall et al., 1986)

(190) **English**
In composing music, Kathy takes [after her father]$_{Manner}$. (Petkevič, 1995)

(191) **English**
Elijah spent his money [to the last penny]$_{Extent}$ on red leather cowboy boots. (Petkevič, 1995)

(192) **English**
Christopher studies [intensively]$_{Extent}$. (Petkevič, 1995)

At the same time, depending on (further) interpretation, we can also have (193), besides (192). The difference is that (193) is understood as expressing that "Christopher is studying in such a way that he does it very intensively."

(193) **English**
Christopher studies [intensively]$_{Manner}$.

3.4.5 INNER PARTICIPANTS

Separately from the above dependency relations, which are mostly free modifiers (except fr **Partitive** and **Identity**), we describe here the so-called (basic) inner participants - **Actor**, **Patient**, **Addressee**, **Origin**, and **Effect**. Included with the discussion of **Addressee** is a discussion of **Beneficiary**.

Actor

The **Actor** dependency relation can modify either a verb, or a noun. We consider the **Actor** as that participant which the meaning of the verb specifies as doing or directly causing something. That act can possibly be intentional (194,195), though it need not necessarily be so (196) (cf. (Sgall et al., 1986), p.114):

(194) **English**
[Elijah]$_{Actor}$ sleeps.

(195) **English**
[Kathy $]_{Actor}$ reads a book.

(196) **English**
[Christopher $]_{Actor}$ fell off a cliff. (Sgall et al., 1986)

Syntactically, the **Actor** is prototypically realized as the surface subject - or, in terms of the relation between form and function in FGD, the **Actor** is "the primary function of the surface subject" (Sgall et al., 1986)(p.111).[30]

Of course, it need not necessarily be the case that every surface subject realizes an **Actor**. The subject of a passive sentence like (197a) does not express the **Actor** of the verbal head (which is *bake*), but its **Objective** (see also 96 below). In (197a) the **Actor** is simply not expressed, whereas in (197b) it is expressed using a *by*-phrase.

(197) a. **English**
[The bread $]_{Object}$ was baked.

b. **English**
[The bread $]_{Object}$ was baked [by Kathy $]_{Actor}$.

As Panevová discusses in (1974), and Sgall *et al.* in (1986)(§2.11), there are also constructions like in (198,199) which, despite of the verb having an "active voice" flavor, are still considered to be passive:

(198) **English**
The bread bakes in the oven.

(199) **English**
The door opens with a key.

Neither the bread in (198) nor the door in (199) is considered in FGD to express an **Actor**. Both times, the sentences can be understood "as synonymous with a passive construction containing a deleted *by*-phrase" (Sgall et al., 1986) (pp.116-117). For English, this perspective may be less straightforward. However, it comes out more naturally when considering constructions labelled *medio-passive* as for example in Slavonic, Romance, or Germanic languages. Medio-passives are constructed using a reflexive particle, like *se* in Czech (200), *zich* in Dutch (201), or *se* in French (202):

---

[30] Thus, the **Actor** is comparable to Tesnière's *premier actant* (1959).

(200) **Czech**

Dveře	se	otevírají	klíčem.	
Doors	REFL-PART	open	by	key-INSTR

"The doors open by a key."

(201) **Dutch**

De	deur	opent	zich	met	een	sleutel.
The	door	opens	REFL-PART	with	a	key.

"The door opens with a key."

(202) **French**

Cette	porte	s'	ouvre	à	clèf.
The	door	REFL-PART	opens	with	key.

"The door opens with a key."

In English, "The door opens with this key" could be considered as a medio-passive construction (Sgall & Hajičová, p.c.), or the rather exotic (203), (Steedman, p.c.).

(203) This wine lends itself to drinking cold.

(204) The following theory suggests itself. (Oehrle, p.c.)

Also nouns can be modified by an **Actor**. Mostly, this occurs with nouns that are derived from actions - like *ing*-forms in English, or verbal nouns in Japanese (Tsujimura, 1996). Syntactically, an **Actor** modifying another noun usually does so in the form of a genitive,[31] indicated in the English (205) by the *'s* and in the Japanese (206) by the morpheme *-no*:

(205) **English**
Kathy has a copy of [[Lichtenstein's $]_{Actor}$ *Cloud and Sea*].

---

[31] More specifically, using that genitival form that expresses this type of relationship, semantically. In Dutch, it seems that a noun in *'s*-genitive case (i) does not lend itself very well to be interpreted as an **Actor** - whereas a *van*-genitive noun easily could (ii).

i. **Dutch**

Rembrandt's	schilderij
of-Rembrandt	painting

"[a] painting of (belonging to) Rembrandt"

ii. **Dutch**

een	schilderij	van	Rembrandt
a	painting	of	Rembrandt

"a painting by Rembrandt"

(206) **Japanese**

[[Rooma-gun-no $]_{Actor}$ sinnyuu-izen], soko-wa sizukana
Romans-GEN invasion-before , there-TOP tranquil
mura dat-ta
village be-PAST

"Before the Roman invasion, that was a tranquil village."
(Tsujimura, 1996), p.140

In other words, the **Actor** noun modifies the head noun "by virtue of" the verb that can be conceived of as bringing about the meaning of the head noun (Sgall et al., 1986) (§4.21).

Patient

The **Patient**, sometimes also called **Objective** (deep Object) or **Goal**, corresponds to the object that is affected by the action denoted by the verbal head it modifies (Sgall et al., 1986)(p.233).[32] Prototypically, the verb's **Patient** is realized as its direct complement:

(207) **English**
Because he fell asleep, Christopher overcooked [the potatoes $]_{Patient}$.

(208) **English**
He had been talking [about his holidays $]_{Patient}$ for hours.

(209) **English**
Consequently, Kathy had to help [to prepare dinner $]_{Patient}$.

Petkevič describes two subdistinctions of **Patient** that can be made in case the verb is a copula: **Temporal Property** and **Permanent Property**. A **Temporal Property** expresses a property that holds for the **Actor** for only a limited time:

(210) Kathy is [the chairperson of the party committee $]_{Temp.Prop.}$.

On the other hand, **Permanent Property** describes a *permanent* property:

(211) Kájík is a [cat $]_{Perm.Prop.}$.

---

[32] For the *e*ffected object, see §3.4.5 below.

As Petkevič remarks, it is interesting to consider the form of Czech sentences like (210) and (211) - whereas the **Temporal Property** is realized using instrumental case (212), a **Permanent Property** is realized as a nominative (213):

(212) **Czech**

Kathy je [předsedkyní $]_{Term.Prop.}$.
Kathy is chairperson-INSTR

"Kathy is a chairperson."

(213) **Czech**

Kájík je kocour.
Kájík is cat-NOM

"Kájík is a cat."

Below I provide a possible specification of the semantic import of **Temporal Property** (214) and **Permanent Property** (215).

(214) **Temporal Property**:

$@_h\langle\textsc{TempProp}\rangle\delta \ \wedge \ @^I{}_h\tau \ \rightarrow$

$@_h\langle\textsc{TempProp}\rangle\delta \wedge @^I{}_h\tau \wedge @_\tau\langle\mathrm{F}\rangle\tau' \wedge \neg(@^I{}_h\tau' \wedge @_h\langle\textsc{TempProp}\rangle\delta)$

"A temporal property is a property for which it holds that at some future time the property no longer holds for the object refered to by head."

(215) $@_h\langle\textsc{PermProp}\rangle\delta \ \wedge \ @^I{}_h\tau \ \rightarrow$

$@_h\langle\textsc{PermProp}\rangle\delta \wedge @^I{}_h\tau \wedge @_\tau\langle\mathrm{F}\rangle\tau' \wedge \neg(@^I{}_h\tau' \wedge \neg@_h\langle\textsc{PermProp}\rangle\delta)$

"A permanent property is a property for which it holds that at any future time the property holds for the object refered to by head."

A more elaborate discussion about the nature of the **Patient** dependency relation can found in (Panevová, 1974), on pages 20-29.

Addressee

The **Addressee** expresses the recipient of an action (Sgall et al., 1986)(p.132). Syntactically, if a verb takes both a **Patient** and a **Addressee**, the **Addressee** is prototypically realized as the "indirect object" or dative:

(216) **English**

Kathy gave a book [to Christopher $]_{Addr.}$.

(217) **Dutch**

Christopher	had	[aan	Elijah	$]_{Addr.}$	om	een	Stetson	gevraagd.
Christopher	had	to	Elijah		for	a	Stetson	asked

"Christopher had asked Elijah for a Stetson."

(218) **Japanese**

Ziroo-ga	[Yosio-ni	$]_{Addr.}$	ringo-o	age-ta.
Ziroo-NOM	Yosio-DAT		apple-ACC	give-past

"Ziroo gave an apple to Yosio."

(219) **Czech**

Elijah	přinesl	[Katce	$]_{Addr.}$	kočku.
Elijah	brought	Kathy-DAT		kitten-ACC

"Elijah brought Kathy a kitten."

A more complex case arises if the valency frame of a verb contains a complementation C that refers to a cognitive role prototypically patterned as **Addressee**, but not one patterned as **Patient**. Then, a certain shift occurs, and C is assigned the valency slot **Patient**. Prototypically, the morphemic expression of this slot is using accusative case. Panevová describes this in more detail in (1974)(pp.30-31), see also (Sgall et al., 1986) (pp.125-127) and (Panevová, 1994). Examples of such shifts are the following:

(220) **English**

As its official chairperson, Kathy addressed [the committee $]_{Addr.}$.

(221) **Dutch**

Elijah	wilde	wel	[op Kájík	$]_{Addr.}$	passen.
Elijah	wanted	alright	on Kájík		take-care-of.

"Elijah didn't mind taking care of Kájík."

(222) **Czech**

Christopher	[kočce	$]_{Addr.}$	nerozumí	.
Christopher	kitten-ACC		not-understand	

"Christopher does not understand the kitten."

Closely related to the **Addressee** dependency relation is the **Beneficiary** dependency relation, the latter being a free modifier. The intended meaning of **Beneficiary** is “to the benefit of someone” (*for whom*). For example, consider (223), (Sgall et al., 1986)(p.199).

(223) **English**
[She]$_{Act}$ sent [Jane]$_{Addr}$ [a sweater]$_{Pat}$ [for her colleague]$_{Benef}$ [to a small town in Wales.]$_{WhereTo}$

Effect

The **Effect** describes the effected object of the action denoted by the verbal head that is being modified. Examples that Panevová gives in (1974) are -among others- predicative complements of verbs like *elect*, *nominate*, or *promote*

(224) **English**
Kathy was elected [chairperson of the committee]$_{Effect}$.

(225) **English**
Nobody else had been nominated [for that job]$_{Effect}$.

(226) **English**
Elijah had already been promoted [to Head Honcho of the cowboy gang]$_{Effect}$.

An interesting pairs of examples is the following, illustrating the difference between **Patient** expressing the *affected* object (227, 229), and **Effect** expressing the *effected* object (228,230):

(227) **English**
Christopher swept [the carpet]$_{Patient}$

(228) **English**
Elijah dug [a hole]$_{Effect}$ with a hoe.

(229) **English**
Christopher told Kathy [about his secret]$_{Patient}$.

(230) **English**
Christopher told Kathy [his secret]$_{Effect}$

Panevová remarks that **Effect** should not be confused with **Result**, since for the latter "such means of realizations as *so that* are typical" (see also (Sgall et al., 1986), p. 134). Moreover, **Result** is a free modifier, allowing for a verbal head to be modified more than once along a **Result** dependency relation, (whereas **Effect** shows no such behavior).

(231) **English**
Chris overcooked the potatoes [so that they burned $]_{Result}$, [resulting in there being no proper dinner $]_{Result}$.

Origin

Finally, the **Origin** is a dependency relation that expresses either the source of the verbal action (232), or -socially- the commonalty of the **Actor** (233):

(232) **English**
Elijah cut a horse [out of wood $]_{Origin}$.

(233) **English**
Christopher comes [from a noble family $]_{Origin}$.

Naturally, an origin does not need to be strictly material:

(234) **English**
Elijah's theory sprung forth [from a simple yet elegant idea $]_{Origin}$.

Origin is not to be confused with **Direction:From Where** or **Cause** as described above in §3.4.2 and §3.4.1, respectively:

(235) **English**
Christopher returned [from the conference $]_{Dir:From}$ all exhausted.

(236) **English**
The blast originated [from a gas leak $]_{Cause}$.

Based on empirical research, both (Panevová, 1974) and (Sgall et al., 1986) posit that **Origin** never occurs as an *obligatory* complement of a verb. It is a specific type of inner participant, which can occur in combinations with various other inner participants (Sgall et al., 1986)(p.134):

(237) **Actor** + **Patient** + **Origin** + **Addressee**:
to hand something over from someone to someone (else)

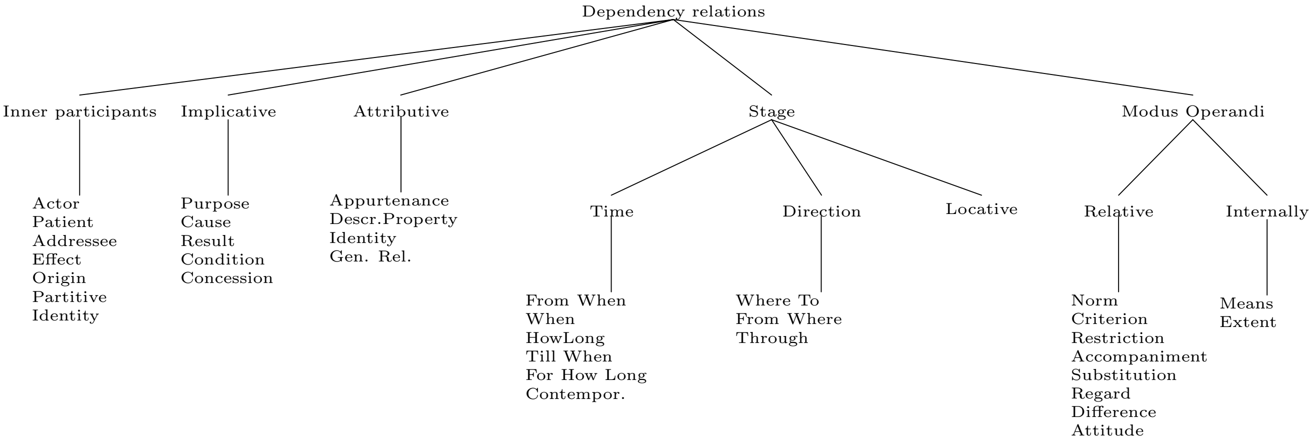

Figure 3.13: A classification of dependency relations

(238) **Actor** + **Patient** + **Origin** + **Effect**:
to change something from something into something (else)

(239) **Actor** + **Origin**:
something grew out of something (else)

3.5 SUMMARY

I focused in this chapter on three important ingredients of (lexical and) linguistic meaning: predicate-valency structures, dependency relations, and aspectual categories. (These are not all the ingredients: information structure is still to be added, and I will do so in Chapter 5.) In brief, predicate-valency frames specify the meaning of a head, and by what dependency relations it has to be modified. A dependency relation determines how the meaning of a dependent contributes to the overall (linguistic) meaning of the head it modifies. Finally, a sentence's underlying aspectual category signifies the discoursive causal and temporal structure it reflects.

For many of the dependency relations I discussed in this chapter, I presented a hybrid logical specification of their semantic import. By a dependency relation's semantic import I mean the extra relations (or entailments) that can be projected: Thus, what do they assert, about the meaning of the dependent itself, and in relation to the meaning of the head that is being modified? This is important. A dependency relation's semantic import may help determine a content verb's aspectual category, as I showed for cases involving causal or temporal dependency relations, or may have to be accommodated in the discourse context for the sentence's linguistic meaning to be coherent, as for example in the case of an attributive reading.

The logical descriptions are couched in a many-sorted hybrid logic, formalizing (and elaborating on) Moens & Steedman's event nucleus (Steedman, 2000b). Combined with the ideas formulated in Chapter 2, and the discussion of predicate-valency structures in this chapter, a more precise picture of linguistic meaning and its representation arises. Representing dependency relations as modal operators makes a formula of the form $head \wedge \langle \rho_1 \rangle \delta_1 \wedge \cdots \wedge \langle \rho_n \rangle \delta_n$ a *relational* structure -which, in DGL, is a tree- rather than a function/argument-structure as we find it in more traditional approaches employing predicate logic. More specifically, the relational structure is a statement about nominals refering to identifiable states in some frame, the relations that are supposed to hold between these states, and what is said to hold at these states. The relational structure is understood to reflect a linguistic patterning found in the surface form - and it is to this extent that it can express meaning.

Now, it is important to observe that its actual *interpretation* is left for the stage of discourse interpretation. That is, only at the level of discourse we tie the nominals into the frame that covers the already established discourse. Moreover, only at this stage we resolve contextual reference, and -if we follow FGD- the scopes of quantifiers, which are left underspecified at the level of linguistic meaning. (Scope resolution arguably relies on the (resolved) information structure, cf. (Sgall et al., 1986)(§3.52) and (Hajičová et al., 1998).) Hence, a sentence's linguistic meaning may be understood to include a certain degree of underspecification, which would make it improper to equate linguistic meaning with e.g. the traditional notion of "truth condition".

To recapitulate, a sentence's linguistic meaning elucidates meaning to the extent that it follows a patterning found in the surface form. The patterning is interpreted as a tree-structure in which dependents modify heads along named dependency relations, and where information structure indicates the perceived relation between the (meanings of the) dependents and the preceding context. Information structure, semantic imports of dependency relations, and the sentence's aspectual category all may project entailments that need to be accommodated in the context for the linguistic meaning to be coherent. In the next Chapter I describe how the dependency-based relational structure of linguistic meaning can be built r as a reflection of an analysis of a sentence's surface form. Chapter 5 then continues with a discussion of how to represent information structure in these relational structures, and Chapters 6 through 8 provide a proposal for how an analysis of structural indications of informativity leads to a reflection of information structure in a sentence's linguistic meaning. Finally, in Chapter 9 I address the interpretation of linguistic meaning in a larger discourse context.

CHAPTER 4

FORM AND FUNCTION IN DEPENDENCY GRAMMAR LOGIC

Dependency Grammar Logic (DGL) is a dependency-based grammar framework in which a categorial calculus is used to analyze form and deliver the kind of representation of a sentence's linguistic meaning as discussed in the previous chapters. This chapter develops the foundations for DGL. I introduce the categorial calculus, and discuss how it can be employed to deliver a dependency-based analysis of form. To that end, I first discuss how head/dependent-asymmetries can be captured, and how morphological strategies can be modeled. Subsequently, I show how linguistic meaning can be formed compositionally, in parallel to the analysis of form. The two principal issues in that discussion are DGL's linking theory, relating predicate-valency structures and syntactic categories, and the interpretation of wordgroups as particular types of dependents. Finally, I present a proposal for how to construct multilingual grammar fragments in DGL, introducing the concept of architecture.

> ... *ὁδὸς ἄνω κάτω μία καὶ ὡυτή*
> ... [the] way up [and] down [is] one and [the] same.
> Heraclitus, *Diels-Kranz 22 B 60*

4.1 INTRODUCTION

In this chapter I lay the foundations for *Dependency Grammar Logic*, or DGL for short. My aim here is to explain how the discussion of the previous two chapters can be related to an extended form of categorial grammars (namely, categorial type logics). The result is the basis for a dependency-based *grammar framework* that follows the Praguian form/function distinction. For one, DGL should enable us to construct grammar fragments that model particular phenomena for a given language, following out a dependency grammar perspective. But there is more: Due to the fundamental role that the (abstract) relations between form and function play, DGL also enables us to develop a *cross-linguistic* perspective on phenomena in natural languages. This latter point is very salient in Praguian linguistics but has, unfortunately, received little or no attention in contemporary formal theories of grammar.

To start off, I begin in section 4.2 with a consideration of the nature of syntactic categories and composition in DGL. I present how categories and composition can be built around the idea of a head-dependent asymmetry, and how dependency relations and morphological information are represented in categories. Subsequently, I work out the linking theory and the categorial-hybrid logical calculus in §4.3. At the end of this chapter I develop the idea of integrating cross-linguistic (or typological, or multilingual) modeling into DGL.

4.2 SYNTACTIC CATEGORIES AND COMPOSITION

In the lexicon, we assign each word a syntactic category. That category is either a *basic category* or a *function category*. A basic category is atomic - for example, N - and indicates that the word does not rely on the presence of further arguments to be provided for that word to enter into a grammatical composition. On the contrary, a functional category specifies one or more arguments that are needed, and a resulting category that is affected once all the arguments have been provided. The familiar slashes $\backslash, /$ are used to indicate the *position relative to the function* where the argument is expected.

Historically, there are two ways in which functional categories can be written. One way is due to Lambek, the other is due to Steedman. The Lambek-notation is characterized by the fact that all the arguments expected to the left are placed to the left of the resulting category, and similarly with all the arguments expected to the right. On the other hand, Steedman's notation puts the resulting category always up front, after which all the arguments follow, again with slashes indicating their directionality. The following examples illustrate the differences - the (a) examples use the Lambek-notation, the (b)-examples use the Steedman-notation. To illustrate more clearly which argument is what, we specify the type of dependent each argument ought to be: $\Diamond_\delta$ means the argument is a dependent of type δ.

(240) **English**

"**Actor** walks."

a. walks $\vdash \Diamond_{Act}N\backslash S$

b. walks $\vdash S\backslash\Diamond_{Act}N$

(241) **English**
"**Actor** gives **Patient Addressee**."

a. gives $\vdash$ $((\Diamond_{Actor}N\backslash S)/\Diamond_{Addressee}N)/\Diamond_{Patient}N$

b. gives $\vdash$ $((S\backslash\Diamond_{Actor}N)/\Diamond_{Addressee}N)/\Diamond_{Patient}N$

(242) **Czech** "čte **Actor Addressee Patient**." (**English**: reads)

a. čte $\vdash$ $((S/\Diamond_{Patient}N)/\Diamond_{Addressee}N)/\Diamond_{Actor}N$

b. čte $\vdash$ $((S/\Diamond_{Patient}N)/\Diamond_{Addressee}N)/\Diamond_{Actor}N$

(243) **Japanese** "**Actor Addressee Patient** ageta" (**English**: gave)

a. ageta $\vdash$ $\Diamond_{Patient}N\backslash(\Diamond_{Addressee}N\backslash(\Diamond_{Actor}N\backslash S))$

b. ageta $\vdash$ $((S\backslash\Diamond_{Actor}N)\backslash\Diamond_{Addressee}N)\backslash\Diamond_{Patient}N$

Throughout the dissertation I use Steedman-style notation. Technically, the Lambek-notation and Steedman-notation are just notational variants (as can be easily verified). From the viewpoint of readability, though, it seems that Steedman-style categories remain more perspicuous even in the presence of detailed information about form - because the resulting category is always clearly located at the beginning.[1]

Definition 11 (Categories valid in DGL). *Given a set of basic categories $\mathcal{B}$, a set of dependency relations $\mathcal{D}$, a set of features $\mathcal{F}$ (e.g. to specify aspects of form), and a set of modes $\mathcal{M}$. Then the set of valid (or well-formed) categories in DGL, $\mathcal{C}_{dgl}$ can be defined as follows.*

1. *Every* basic *category $\mathsf{C} \in \mathcal{B}$ is a well-formed category: $\mathsf{C} \in \mathcal{C}_{dgl}$.*
2. *Given two categories $\mathsf{C}_i, \mathsf{C}_j \in \mathcal{C}_{dgl}$ and a mode $\mu \in \mathcal{M}$, then the following categories are also in $\mathcal{C}_{dgl}$: $(\mathsf{C}_i\backslash_\mu\mathsf{C}_j), (\mathsf{C}_i/_\mu\mathsf{C}_j), (\mathsf{C}_i \bullet_\mu \mathsf{C}_j)$, with C_i the resulting category.*

Furthermore, let the modal prefix ϖ *of a category be that sequence of unary modalities $\Diamond$, $\Box^{\downarrow}$ that prefixes a category C, with C being either basic, or of the form $(\mathsf{C}_i\backslash\mathsf{C}_j), (\mathsf{C}_i/\mathsf{C}_j), (\mathsf{C}_i \bullet \mathsf{C}_j)$. Then, the following categories are also valid in DGL:*

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[1] There are also some computational "arguments" - Steedman-style categories are more convenient when it comes to parsing categorial type logics, cf. (Kruijff, 1999b).

3. *Given a dependency relation* $\delta \in \mathcal{D}$*, and a category* $\varpi\mathsf{C}$*, then the following categories are also in* $\mathcal{C}_{dgl}$ *iff* $\Diamond_\delta$ *does not appear in the modal prefix* ϖ*:* $\Diamond_\delta\varpi\mathsf{C} \in \mathcal{C}_{dgl}$*.*

4. *Given a feature* $\phi \in \mathcal{F}$*, and a category* $\varpi\mathsf{C}$*, then the following categories are also in* $\mathcal{C}_{dgl}$ *iff there is no (modalized) feature* ϕ' *in* ϖ *that would -linguistically- contravene with* ϕ*:* $\Box^{\downarrow}{}_\phi\varpi\mathsf{C}, \Diamond_\phi\varpi\mathsf{C} \in \mathcal{C}_{dgl}$*.*

Valid categories are all those categories that can be specified on the basis of steps 1-4; nothing else is a valid category in DGL. ⊛

Remark 10. A few remarks are in place. Steps 1 and 2 build up $\mathcal{C}_{dgl}$ in a straightforward way. Following the traditional formulations of categorial type logics (cf. (Hepple, 1994; Moortgat, 1997; Morrill, 1994)) we include products $\bullet_\mu$ (pairing), besides slashes $\backslash_\mu, /_\mu$. Step 3 defines categories involving the specification of dependency relations, in such a way that we exclude the possibility to specify one argument to be interpretable as two dependency relations:

(244) a. the category $(S\backslash_{\succ sc}\Diamond_{Actor}\Diamond_{Patient}N)$ is invalid, because an argument cannot be a verb's **Actor** as well as its **Patient**.

b. the category $((S\backslash_{\prec sc}\Diamond_{Actor})/_{dc\succ}\Diamond_{Patient}N$ is valid

Step 4 avoids the situation in which one and the same category gets specified as having, for example, both a nominative and an accusative inflection.[2] ⊛

4.2.1 THE HEAD/DEPENDENT ASYMMETRY

How do we incorporate the idea of a head-dependent asymmetry into our categories? To begin with, it has been often observed in the past that the functional categories found in categorial grammar incorporate already an idea of a distinction between heads and dependents. Bar-Hillel, after all, considered categorial grammar to be a *dependency grammar* and not a constituency grammar. Among the first to explore the idea of representing a head-dependent asymmetry in categorial grammar in more depth was

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[2] Note that if the category would be assigned to a word that is morphologically *ambiguous* between being nominative or accusative, then such should be captured using an underspecified morphological marking - cf. (Heylen, 1999) and the discussion about underspecification below.

Venneman (1977). Contemporary proposals for including a notion of head in categorial grammar include Barry and Pickering (1992), Moortgat and Morrill (1991), and -based upon the latter proposal- Moortgat and Oehrle (1994), and Hepple (1994; 1996b; 1997).

Moortgat and Morrill develop in (1991) a calculus that aims at combining the notion of constituency or phrasal structure (i.e. linearization), and head-dependent asymmetry. Although their effort looks similar to what Venneman set out to do in his (1977), this time just using the more powerful categorial type logics, this would nevertheless not be correct. Whereas Venneman sought to combine constituency/linearization and a head-dependent asymmetry using the function/argument structure of categories, this is exactly what Moortgat and Morrill are *not* trying to do:

> "The important point here is that we consider the dependency asymmetry as an *autonomous* dimension of linguistic organization - a dimension which may cross-cut the distinctions that can be made in terms of the function/argument opposition." (1991)(p.15).

Moortgat and Morrill contrast their ideas with approaches where a head-dependent asymmetry is *defined* in terms of function/argument structure, like Barry and Pickering's (1992), arguing that in such theories "[headedness] is a derivative concept just employed in elucidation." (*ibid.*) Whether we agree with this position or not is not the point at the moment - let us first have a closer look at their proposal, which formed the inspiration for many others to follow later.

Moortgat and Morrill start off discussing how constituency can be handled by categorial type logics of a fairly limited power - namely, the nonassociative Lambek-calculus NL and the associative calculus L. One of the downsides of the associative Lambek-calculus L is its insensitivity to domains of constituency: The immediate constituency hypothesis gives rise to a fairly rigid bracketing scheme, which the L is of course impervious to due to its associative character. Moortgat and Morrill discuss how a combination of NL and L lead to a (hybrid) calculus that not only overcomes this apparent problem, but -more importantly- gives rise to the well-known notion of "flexible constituency".

Subsequently, Moortgat and Morrill present a non-associative calculus in which it is explicitly represented which of the two components in a binary structure is the head. As Morrill clarifies later in his (1994)(p.88ff), the calculus developed in (Moortgat and Morrill, 1991) is essentially NL with subscripts l and r added to its operators. The l marks that in a binary structure the left constituent is the head, whereas r indicates that the right constituent is the head.

Though simple in nature, the proposal makes essential use of the possibilities of categorial type logics to control the construction of trees. For example, structural rules for associativity are given that show how headedness is preserved over rebracketing (even though constituency structure is, obviously, changed). Moortgat and Morrill illustrate their approach on metrical trees, which are binary trees in which each mother node marks one daughter node as strongly stressed and another as weakly stressed.

With metrical trees, Moortgat and Morrill try to make a case for their argument that headedness should be considered as a primitive concept, not as one derived from function/argument structure. For example, consider their example (44)(p.17), here given as (245):

(245) **English**

"What happened?"

a. John arrived.

b. John left.

Moortgat and Morrill point out that the neutral utterance of (245(a)) has stress on "John" - stress on the verb would put the verb 'in focus'. On the other hand, neutral utterance of (245(b)) has the stress on the verb. Using l/r to indicate which constituent receives stress, we can represent the examples as the following metrical configurations (246).

(246) (Moortgat and Morrill, 1991)(Example 45, p.17)

a. $[_l$ John arrived]

b. $[_r$ John left]

Then, to quote Moortgat and Morrill,

> "Observe that any attempt to characterize prosodic structure purely in terms of the function/argument asymmetry would have to treat the two verbs on a par: here then we see an example of the autonomous character of the dependency dimension." (1991)(p.17)

Moortgat and Morrill close their discussion with remarking that the calculus they develop can model different types of dependency - not just the prosodic perspective they take, but for example also syntactic or semantic types of dependency.

Let us return then to Moortgat and Morrill's point that phrasing a head-dependent asymmetry in terms of function/argument-structure misses the point: function/argument-structure elucidates linearization, and the head-dependent asymmetry might cut across that. In other words, linearization and dependency are two different dimensions, and should therefore be kept separate. For example, consider the prototypical category for a sentential adjunct, like a temporal adverbial: $S \backslash S$. This category is a function, taking a verb as its argument. However, the head-dependent asymmetry is exactly the opposite, as the verb governs the temporal adjunct. A template for an appropriate categorial assignment would thus be $S \backslash_{*\succ} S$.

Sgall *et al.* make the same point, though in a different guise - "The relationships between a head (governor) and its modifications, rather than relative closeness (constituency) are what dependency grammars are based on [...]" (1986)(p.136). From the viewpoint of dependency grammar, the point that Moortgat and Morrill stress is perhaps not as striking as it may appear - dependency grammarians have always considered dependency to constitute a different dimension. Venneman phrased this very nicely: constituency deals with horizontal organization, dependency deals with vertical organization. And not only in dependency grammar this idea has surfaced. For example, GPSG and HPSG also distinguish two separate dimensions, as expressed by their tree admissibility conditions: ID-rules state hierarchical relationships, and LP-rules specify linearization relations (Gazdar et al., 1985; Pollard and Sag, 1993).

It is this point, that linearization and dependency structure are *not* isomorphic but represent orthogonal dimensions, that we should bear in mind. What Moortgat and Morrill can be understood to argue for is *not* that we cannot use function/argument structures to represent a head-dependent asymmetry - we can, but the directionality of the slashes need not mirror the head-dependent asymmetry, nor is it the case that structural rules controlling linearization necessarily lead to changes in dependency structure.

With that in mind, let us now turn to Hepple's proposal. Hepple originally developed an approach of locality (head-domains) in his dissertation

(1990), based on Morrill's use of unary modals to model locality in the context of binding (1990; 1994). Simply put, unary modals would mark the boundaries of a domain. Hepple critically reflects on this approach though in (1994; 1997), making the point that his approach allowed the specification of boundaries to be decoupled from other aspects of structure - thus rendering the specification rather stipulative. Instead of using unary modals, Hepple therefore switches for Moortgat and Morrill's original proposal to encode information regarding head/dependent asymmetries directly on $\{\backslash, /, \bullet\}$. What makes Hepple's discussion in (1994; 1997) particularly interesting is that Hepple adds some explanatory notions like R-*heads,* R-*dependents*, and a discussion of head domains - all of which will prove to be useful.

4.2.2 CATEGORIES AND COMPOSITION

How can we define how categories do compose? To begin with, we need to define a nonassociative calculus that serves as our basis. Again, we take a (labelled) natural deduction formulation of what Moortgat and Oehrle call "the logic of pure residuation". This logic defines the basic behavior common to *all* $\{\backslash_\mu, /_\mu, \bullet_\mu\}$ and $\Diamond_i, \Box^{\downarrow}{}_i$, and is therefore sometimes also called the "base logic". Note that we do *not* yet define the operations on the semantics isomorphic to the operations on the categories.

Definition 12 (Proof calculus of pure residuation). *The proof calculus of pure residuation, equivalent to the formal part of the nonassociative Lambek calculus* NL*, is defined as follows. Given any modality* μ *in* $\mathcal{M}$*, the set of modalities,*

$$\frac{\alpha \vdash A \qquad \beta \vdash (B \backslash_\mu A)}{(\alpha \circ_\mu \beta) \vdash B}\, E\backslash_\mu \qquad \frac{\beta \vdash (B /_\mu A) \qquad \alpha \vdash A}{(\beta \circ_\mu \alpha) \vdash B}\, E/_\mu$$

$$\frac{\begin{array}{l}[\alpha \vdash A]\cdots \\ \quad\vdots \\ \qquad\qquad (\alpha \circ_\mu \beta) \vdash B\end{array}}{\beta \vdash (B \backslash_\mu A)}\, I\backslash_\mu \qquad \frac{\begin{array}{r}\cdots[\alpha \vdash A] \\ \vdots\quad \\ (\beta \circ_\mu \alpha) \vdash B \qquad\qquad\end{array}}{\beta \vdash (B /_\mu A)}\, I/_\mu$$

$$\dfrac{\begin{array}{c}[\gamma \ \vdash \ B] \quad [\zeta \ \vdash \ C]\\ \vdots \\ \alpha[(\gamma \bullet{}_\mu \zeta)] \ \vdash \ A\end{array} \qquad \beta \ \vdash \ (B \bullet{}_\mu C)}{\alpha[\beta] \ \vdash \ A}\, E \bullet{}_\mu \qquad \dfrac{\alpha \ \vdash \ A \quad \beta \ \vdash \ B}{(\alpha \circ_\mu \beta) \ \vdash \ A \bullet{}_\mu B}\, I \bullet{}_\mu$$

For the unary modals we have the following rules defining residuation. In $E\Diamond$ *we allow for the elimination of a diamond* $\Diamond_j$ *by a less specific* $\Diamond_i$ *while retaining mode* j.

$$\dfrac{\alpha \vdash A}{\langle\alpha\rangle^i \vdash \Diamond_i A}\, I\Diamond \qquad \dfrac{\alpha \vdash \Diamond_i A \quad \begin{array}{c}[\gamma \vdash A]\\ \vdots \\ \beta[\langle\gamma\rangle^j] \vdash B\end{array}}{\beta[\alpha] \vdash B}\, E\Diamond$$

$$\dfrac{\langle\alpha\rangle^i \vdash A}{\alpha \vdash \Box^{\downarrow}{}_i A}\, I\Box^{\downarrow}{}_i \qquad \dfrac{\alpha \vdash \Box^{\downarrow}{}_i A}{\langle\alpha\rangle^i \vdash A}\, E\Box^{\downarrow}{}_i$$

Note that we have defined these rules for Steedman-style notation of categories.$\circledast$

Remark 11 (Pure residuation defines strict concatenation.). The calculus given in Definition 12 only enables us to model a very restricted form of concatenation. Later on, we will relax the rigidity that the calculus imposes, by adding structural rules that enable us to modify structures (represented in the labels before the turnstyle $\vdash$) in a controlled fashion. $\circledast$

In DGL we use the arrows $\prec$, $\succ$ as a notation for headed modes. This notation is reminiscent from dependency grammar (for example, see Hudson's Word Grammar or Mel'čuk's Meaning-Text Model), with the arrow pointing *from* the head *to* the dependent - see Figure 4.1 for two examples of dependency structures (arc- versus tree-representation). In a structure $(x \succ y)$, x is the head and y the dependent, whereas in $(x \prec y)$ x is the dependent and y the head.

Rather than a single couple of modes $\succ$, $\prec$, we distinguish *various* modes, depending on the nature of the head (and sometimes, that of the complementm, as for *sc*). Each mode $*\!\succ$ or $\prec\!*$ comes fully equipped with a product and its residuals, i.e. we have $\{\backslash_{*\succ}, /_{*\succ}, \circ_{*\succ}\}$ and $\{\backslash_{\prec *}, /_{\prec *}, \circ_{\prec *}\}$. This naturally follows from the basic law of residuation $A \rightarrow B/_i C$ iff $A \circ{}_i B \rightarrow$

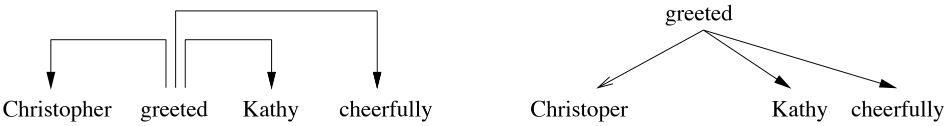

Figure 4.1: Simple dependency structure

C iff $B \rightarrow A\backslash_i C$, and -albeit intuitively- from the fact that we regard dependency ($*\!\succ, \prec\!*$) and linearization ($\{\backslash, /, \circ\}$) as separate dimensions.

Remark 12 (Endo-/exocentricity can model obligatoriness/optionality). Following Bloomfield, and Venneman's discussion in (1977), we can make a distinction between an *endocentric category* and an *exocentric category.* An endocentric category is a function category in which the head of the resulting construction is provided by the function category itself. On the contrary, an exocentric category is a function category in which the head of the resulting category is provided by an argument of the category.[3] Examples of endocentric categories are categories for verbs like $(S\backslash_{\prec sc}\Diamond_{Actor}N)$ or $(S \backslash_{\prec sc}\Diamond_{Actor}N)/_{dc\succ}\Diamond_{Patient}N$. Exocentric categories are usually assigned to adverbials (prototypically of the form S/S) or adjectives (prototypically of the form N/N).

The important point of making this distinction is that it enables us to -in a sense- complete the account that DGL gives of FGD's valency combinatorics. As I already discussed earlier, the exact modal character of a dependency relation in a predicate-valency structure determines its behavior as an inner participant or free modifier. Furthermore, obligatoriness of arguments is modeled in a rather obvious way, by including them in the endocentric category of the head they are obligatory arguments *to.* Optionality I model in DGL using exocentric categories, and a lexical meaning that adds the meaning of the dependent to that of the head it modifies. An exocentric category for an optional argument of a head with resulting category C is prototypically specified as $C/_{\prec *}C$ or $C\backslash_{*\succ}C$. The meaning of the argument essentially is a recipe that takes the meaning of the head and conjoins the meaning of the argument to it, using the appropriate dependency relation. ⊛

To illustrate how $*\!\succ$ or $\prec\!*$ modes work, we begin by considering the structures presented earlier in Figure 4.1. Omitting information about de-

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[3] See for similar perspectives (Malmkjæ, 1996)(p.218,276) or (Pollard and Sag, 1993).

pendency relations for the moment, the proof in (247) illustrates how these structures would be derived.

$$(247)\quad \dfrac{\dfrac{\text{Christopher} \vdash N \qquad \dfrac{\text{greeted} \vdash (S\backslash_{\prec sc}N)/_{c\succ}N \quad \text{Kathy} \vdash N}{(\text{greeted} \circ_{c\succ} \text{kath}) \vdash (S\backslash_{\prec sc}N)}\, E/_{\mu}}{(\text{Christopher} \circ_{\prec sc} (\text{greeted} \circ_{c\succ} \text{kath})) \vdash S}\, E\backslash_{\mu} \qquad \text{cheerfully} \vdash S\backslash_{a\succ}S}{((\text{Christopher} \circ_{\prec sc} (\text{greeted} \circ_{c\succ} \text{kath})) \circ_{a\succ} cheerfully) \vdash S}\, E/_{\mu}$$

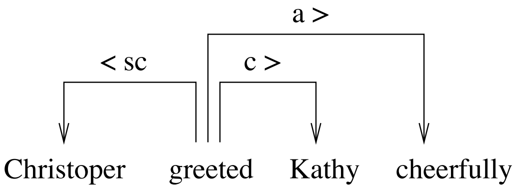

Figure 4.2: Simple dependency structure

The linear structure (the *label*) $((\text{Christopher} \circ_{\prec sc} (\text{greeted} \circ_{c\succ} \text{kath})) \circ_{a\succ} cheerfully)$ represents the structure in Figure 4.2. One immediately observable difference between the linearized form and the structure in Figure 4.2 is that the latter is *flat*, whereas the linearized form has more internal structure in the form of bracketing. The bracketing arises from our use of binary composition, whereas flatter structures like in Figure 4.2 arise from n-ary composition. The flatter structures give a clearer picture of the *domain of the head* (or head domain).

To bridge this apparent gap, we could of course add n-ary implications and products, following (Moortgat, 1995), and define composition between heads and their modifiers in terms of n-ary connectives rather than binary ones. The relation between n-ary connectives and binary ones is simple, though: n-ary connectives are a generalization of the latter, by using functional composition ("Shoenfinkel's trick"). Yet precisely *because* binary connectives are total functions enabling one to apply functional composition, the generalization that n-ary connectives present adds nothing new, except for a different way of writing composition.

Remark 13 (N-ary composition in CTL). A formal calculus for Moortgat's algebraic discussion (1995) could be the following:

$$\dfrac{h \vdash \div_{\star}\{H, C_1, ..., C_n\} \quad c_1 \vdash C_1 \cdots c_n \vdash C_n}{\{h_{>}c_{1>}..._{>}c_n\}_{\star} \vdash H}\, E \div_{\star}$$

A version in which the type would specify the resulting type to obtain from arguments coming from the left as well as the right is just a notational variant and we will therefore not consider it here. Note that a more incremental version of the elimination rule above could be made to allow for arguments to combine in arbitrary order. These rules would thus mimick the rules of Baldridge (1999)'s curly bracketed types in Set-CCG, derived from Hoffman (1995a). However, such an approach would not be in keeping with CTL: word order is a phenomenon to be modelled by structural rules, not by the base logic. Instead, we obtain incrementality through the following introduction rule:

$$\frac{\{\Gamma[c]\}_\star \vdash H \quad [c \vdash C]}{\{\Gamma - c\} \vdash \div_\star\{H, C\}}\, I \div_\star$$

⊛

I did explore the use of n-ary connectives in (Kruijff, 1998), but afterwards had to conclude that the use of n-ary connectives led to fairly unreadable structural rules detailing feature distribution (as used for example in morphology - see §4.3.1 below). Therefore, I opt for a different approach, namely the one adopted by Hepple in (1997). To enable one to talk of structures like we obtained in (247) above, Hepple introduces the (sensible) notions of R-*head* and R-*dependent*. Hepple defines these two notions recursively - in a structure like $((y \prec x) \succ z)$ the (atomic) x is considered to be the R-head, whereas y and z are x's R-dependents.[4]

The domain of a head can therefore be loosely defined as the structure of an R-head and its R-dependents. If we would only have the calculus given in Definition 12, this would give rise to a very strict notion of locality, not having any structural rules to enable different ordering or rebracketing. Naturally, this proves to be too restrictive to be linguistically interesting. It is then to structural rules operating on headed structures that we must turn, and see how we can give more shape to (language-specific models of) head-domains and the (flexible) locality they give rise to.

Remark 14 (Product trees versus process trees.). To round off the discussion on headed composition, let us consider the difference between the linear structure in (247), and the dependency structure in Figure 4.2.

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[4] In other words, y and z are "the 'immediate dependents' of the 'projections' of x." (Hepple, 1997)(p.6).

The bracketing in (247) reflects the *steps* taken in *deriving* the composed structure, and can be used to guide further derivation steps. This makes the tree structure of (247) a tree representing a *process perspective.* On the contrary, this is not the chief purpose of a structure like Figure 4.2. Rather, a dependency structure can be understood to represent the *product* of a derivation. These different perspectives (product versus process) are not mutually exclusive, though. It is easy to see that if we employ Hepple's notions of R-head and R-dependent to interpret the linear structure in (247), then we obtain exactly the dependency structure in Figure 4.2. Hepple's recursive notions abstract away from the individual steps in deriving the composition of a head and its dependents, leaving us with binary, immediate relations between a head and a dependent it governs. ⊛

4.3 RELATING FORM AND FUNCTION

In the previous chapter, I discussed the issue of a sentence expressing linguistic meaning. The basic components of a sentence's linguistic meaning, as discussed in that chapter, were event nuclei expressing the aspectual categories of eventualities, and dependency relations that contribute to the further specification of an eventuality.[5] Following Moens and Steedman (1988) and (Steedman, 2000b), I already briefly explained how aspectual categories relate to their expression (form) in verbal tense and aspect (see also (Steedman, 2000b)). In the current section, I focus on the relation between form and dependency relations - by what forms are dependency relations realized, or conversely, how do we recognize by the form of a word group what type of dependent it is?

Within the Prague School of Linguistics, the issue of the relation between the *form* of a word and the *function* of the word's meaning in the underlying meaning of the sentence has taken in a central place ever since the pioneering work by -among others- Jakobson and Mathesius. Particularly illustrative of the importance of *distinguishing* the form-function relation is Mathesius' programmatic contribution to the *Travaux* in 1936. There, Mathesius outlines the advantage of describing natural language grammars from the viewpoint of functions rather than forms (criticizing Jespersen's *Essentials* on the way) since it is functions that are shared *across* languages:

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[5] In the second part of my dissertation, a third component is added, namely information structure - following (Sgall et al., 1986).

> “If we are to apply analytical comparison with profit, the only way of approach to different languages as strictly comparable systems is the functional point of view, since general needs of expression and communication, common to all mankind, are the only common denominators to which means of expression and communication, varying from language to language, can be reasonably brought.”
> – (Mathesius, 1936)(p.95/306)

Here, I build forth on ideas worked out in the Prague School of Linguistics during the interbellum by Jakobson, Mathesius, Skalička, and Trnka, work that set the basis for later work by Daneš, Dokulil, Kuryłowicz, and Sgall and his collaborators - cf. (Sgall et al., 1986)(§2.10) and (Panevová, 1994). The principal idea is to distinguish a *morphological category of Case*, or abstract case, from actual morphological strategies. This distinction is similar to the idea of abstract case in Government & Binding theory, cf. (Haegeman, 1991).[6] An abstract case mediates between dependency relations and morphological strategies that express dependency relations. The key idea is that these Cases abstract away from language-specific form. Each language has its own *morphological exponents* (Trnka, 1932) or *morphological strategies* (Croft, 1990) to express the different abstract Cases at the level of surface form, and thus the dependency relations associated with them. For example, a **Patient** is related to the abstract case Accusative, and across languages we find different ways in which the Accusative can be expressed: Czech and German use inflection, Japanese uses an affix $-o$, and English has a particular (canonical) position.

It is worthwhile to reflect a bit on the picture that thus arises. At one end, we have dependency relations that are essential to structuring linguistic meaning. At the other far end, we have the outer form of sentences. Now, this apparent chasm between form and different argument roles has been

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[6] Two sideremarks should be made. First of all, Case naturally concerns those deverbitive/denominative dependents that are themselves nominal or adjectival groups. Secondly, Case should be kept apart from morphological categories like number, gender or delimitation. Sgall et al mention in (1986) only number and delimitation as morphological categories for nouns (pp.172-173). Mathesius discusses in (1936) *four* morphological categories for nouns, namely *number*, *totality*, *definiteness*, and *qualitative gender* (as opposed to purely morphological gender). Sgall *et al.*'s description of *delimitation* basically covers Mathesius' totality and definiteness (where totality is the distinction illustrated by **French**.*un pain*, *du pain*, *les pains*, *des pains*). The inclusion of gender here as a morphological category is *not* Mathesius' qualitative gender, but morphological gender - his qualitative gender corresponds to our distinction of gender at the level of lexical meaning.

criticized by various authors, e.g. Dowty, Davis, and Wechsler. How could one possibly recognize the role of a particular argument? The answer presented here, having its roots in work done in the Prague School of Linguistics since the 1930s, is that we can distinguish *language-specific* morphological strategies that realize *language-universal* dependency relations, and their relation is mediated through language-universal morphological categories.[7]

Let me consider a few additional examples to illustrate what we have in mind here (cf. also (Kuryłowicz, 1964; Sgall et al., 1986; Sgall et al., 1996)). The dependency relation **Patient** is mostly expressed by an accusative case, which in Czech is reflected by inflection:

(248) **Czech**

Honza	koblihu	snedl .
Honza-NOM	donut-ACC	ate

"Honza ate the donut."

(249) **Japanese**

Susi-o	Taro-ga	tabeta.
Sushi-ACC	Taro-NOM	ate

"Taro ate sushi."

Neither in Japanese (249) nor in Czech (248) the expression of accusative case is dependent on word order. This stands in contrast to analytic languages likeEnglish, which do not have an accusative inflection but realize the accusative case through placing the wordform in the direct complement position (directly after the verb):

(250) **English**

Christopher read the book.
the book-ACC

Similarly, the **Actor** dependency relation is prototypically realized by a nominative case (i.e. in sentences in active voice). Again, synthetic languages like Czech (251) or Japanese (252) make use of inflection, whereas

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[7] Although it might be tempting to say that morphological categories "realize" dependency relations, this wouldn't be correct. It is the morphological strategies that realize dependency relations, and we view the relation between morphological strategies and dependency relations as *mediated through* abstract morphological categories.

analytic languages like English (253) employ word order, indicating nominative case by placement in subject position:

(251) **Czech**

Honza	koblihu	snedl.
Honza-NOM	donut-ACC	ate

"Honza ate the donut."

(252) **Japanese**

Hanako-ga hon-o katta.
Hanako-NOM book-ACC bought

"Hanako bought a book."

(253) **English**

Kathy	despises John Wayne movies
Kathy-NOM	

Other examples are the use of the dative case to realize the **Addressee** dependency relation. In Japanese the dative is formed using the *-ni* postposition, Czech has a dative inflection, whereas in English and in Dutch dative case is reflected by placement in the indirect object position or use of a function word like **English** "to" or **Dutch** "aan".

All the examples above illustrate the *prototypical* use of cases to realize a specific dependency relation. Kuryłowicz (1964) calls these dependency relations the *primary functions* of the respective cases - i.e. a case's primary function is that dependency relation which it usually realizes (p.16). Opposite to a case's primary function is its secondary function - that dependency relation which it can realize as well, but only in what Sgall *et al.* call "contextually conditioned items" in (1996)(p.71). For example, Sgall *et al.* consider the following oppositions in the use of the accusative - once realizing its primary function, **Patient** (254), and once its secondary function, the **Time:How Long** (255):

(254) Christopher read the entire book.

(255) Christopher read the entire night.

Sgall *et al.* also mention that the Accusative has in Sanskrit as its secondary function **Direction:Where To**:

(256) **Sanskrit**

vanam	gacchati	(Sgall et al., 1996)(p.72)
go-3-SING	forest-ACC	

"S/he goes into the forest"

The interesting point about (256) is that in both Germanic languages and Slavonic languages the Accusative displays similar behavior, when combined with particular propositions. For example, in German the preposition *auf* when combined with a nominal group in accusative case realizes **Direction:Where To** (here: "onto X"), and so does the Czech proposition *na* when combined with an accusative.

To recapitulate, we make a distinction between morphological strategies and morphological categories. We connect dependency relations to morphological strategies through morphological categories, whereby we can discern primary and secondary functions for the latter. Morphological strategies are language specific, and morphological categories are assumed to be language universal[8]. Put together, we not only advance the hypothesis that with this setup we can explain the relation between a sentence's form and its linguistic meaning. Equally important, the intention is to present an account that might find a validity that applies *cross-linguistically* - and with that, it goes well beyond the accounts of Wechsler (1995) or Davis (1996).

In section §4.3.1 below I discuss morphological strategies in some more detail, explaining how for example *case marking*, *adposition*, *positioning* or *linking* can be modeled in DGL. Section §4.3.2 continues the story: Here, I detail out how one derives the category of a word, given its lexical meaning. Finally, section §4.3.3 rounds it all of, completing the calculus presented earlier such that linguistic meaning is built compositionally.

4.3.1 Modeling morphological form

Following Croft's discussion in (1990)(Ch.2), one can distinguish for example the following morphological strategies (257) that a language may employ to realize a particular morphological category.

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[8] Though they need not always be "available" in a particular language.

(257)
a. *case*: The use of bound morphemes or *case markers* to indicate the morphological category.
b. *adposition*: A morphological category is signalled by a *function word* affixed to the wordform.
c. *positioning*: The wordform's position in the clause, relative to for example the main verb, is an indication of the underlying morphological category.
d. *linker*: A linker is an invariant marker, or morpheme, that relates the modifier and the modified. Unlike the above three strategies, linkers are not used for verb-noun modification; only noun-noun modifications are linked.[9]

These strategies are illustrated in (258) through (261). Particularly (261) is interesting since it exemplifies how strategies can be combined.[10]

(258) *positioning*
a. **English**
Elijah wrote **a letter**, *accusative* (direct complement position)
b. **Dutch**
dat Elijah **Kathy** een boek gaf, *dative* (indirect complement position)

(259) *case*
a. **Czech** knih-**a**, *nominative*; **Czech** knih-**u**, *accusative*
b. **German des** Kind-**es**, *genitive*

(260) *adposition*
a. **Dutch aan** Kathy, *dative*
b. **Japanese** Kathy-**ni**, *dative*

(261) *linking*
a. **English**
Elijah**'s** cowboy-boots, *genitive*

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[9] Note that if a linker morpheme is used only for the possessive, and not for either predicate-argument relations or any other modifier-noun relation, then it may be difficult or even impossible to distinguish a linker from e.g. a case marker or an agreement marker; cf. (Croft, 1990),p.32.

[10] Note: except for the Japanese examples, the '-' in each example only serves to illustrate the case marker separately from the root. Normally, no hyphens are used.

b. **English**
the cowboy boots **of** Elijah**'s**, *genitive*
(linking+adposition), (Croft, 1990)(p.33)

In the next sections we discuss how we can model in DGL the morphological strategies positioning (§4.3.1), case (§4.3.1), and adposition (§4.3.1)

Morphological strategies: Positioning

I can be fairly brief about how to model positioning in DGL. The reason is that a system like the Lambek calculus by its very nature provides all the necessary ingredients - namely, composition and *type-raising*. Type-raising is the creation of a category C' from a category C such that C' is a function that takes as its argument a function that takes C as its argument. CCG includes rules for type-raising in its basic calculus (the **T**-combinator, cf. (Steedman, 2000c)(p.43ff)). In categorial type logic, type-raising is a theorem for all those modes that have access to (full) associativity (cf. (Oehrle, 1994; Moortgat, 1997)). Example (262) gives an illustration of type-raising.

(262) $N \;\; =\!\![\text{type-raising}]\!\!\Rightarrow \;\; S/(S\backslash N)$

Steedman proposes to use type-raising to model positioning. The intuitions are simple, and can be illustrated on example (262). What the type-raising in (262) effectively does is turning the noun into a category stating that the noun should appear in subject-position. That is, the category specifies the noun as *nominative "case"*, as illustrated in (263). Note that we make use of the specification of δ as *Actor* in diamond elimination.

(263)
$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{nom \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta}N}{\langle nom\rangle^{case} \vdash \Diamond_{\delta}N}[E\Box^{\downarrow}]}{\langle nom\rangle^{nom} \vdash \Diamond_{\delta}N}\mathit{Spec} \quad \dfrac{\dfrac{[\gamma \vdash N]^{2}}{\langle\gamma\rangle^{Actor} \vdash \Diamond_{Actor}N}[I\Diamond] \quad [\mathrm{r}_{0} \vdash \Box^{\downarrow}{}_{act}n\backslash_{<sc}s]^{1}}{\langle\gamma\rangle^{Actor} \circ_{\prec sc} r \vdash S}[E\backslash]}{\langle nom\rangle^{nom} \circ_{\prec sc} r \vdash S}[E\Diamond]}{\langle nom\rangle^{nom} \vdash \Diamond_{Actor}N/_{\prec sc}(\Diamond_{Actor}N\backslash_{\prec sc}S)}[I/]^{1}}{nom \vdash \Box^{\downarrow}{}_{nom}(\Diamond_{Actor}N/_{\prec sc}(\Diamond_{Actor}N\backslash_{\prec sc}S))}[I\Box^{\downarrow}]$$

Similar categories can be specified for other "cases", like the English dative (indirect object position) and accusative (direct object position).

Morphological strategies: Case

Heylen (1999) proposes an approach to handling featural information in the setting of categorial type logics. The leading parts in Heylen's approach are played by named instances of the unary modal operators $\Diamond$ and $\Box^{\downarrow}$. The idea is to give the boxes names, like we give names to modes. Particularly, as names we can use the names of morphological features, like *fem* (feminine), *acc* (accusative) and so on. Then, by prefixing a type with such boxes, we can specify its morphological features. For example, (264) states that to the token **Czech** "kniha" (**English** book) we can assign the type specifying "kniha" as a feminine noun in nominative case, singular.

(264) $kniha \vdash \Box^{\downarrow}{}_{fem}\Box^{\downarrow}{}_{nom}\Box^{\downarrow}{}_{sing}n$

The $\Box^{\downarrow}$'s come into play in a proof by eliminating them from the type, thus introducing them as explicit information in the structure. For example, applying $E\Box^{\downarrow}$ to $kniha \vdash \Box^{\downarrow}{}_{fem}\Box^{\downarrow}{}_{nom}\Box^{\downarrow}{}_{sing}n$: *book* leads to the following:

(265)
$$\dfrac{\dfrac{\dfrac{kniha \vdash \Box^{\downarrow}{}_{fem}\Box^{\downarrow}{}_{nom}\Box^{\downarrow}{}_{sing}n}{\langle kniha\rangle^{fem} \vdash \Box^{\downarrow}{}_{nom}\Box^{\downarrow}{}_{sing}n}\,E\Box^{\downarrow}}{\langle\langle kniha\rangle^{fem}\rangle^{nom} \vdash \Box^{\downarrow}{}_{sing}n}\,E\Box^{\downarrow}}{\langle\langle\langle kniha\rangle^{fem}\rangle^{nom}\rangle^{sing} \vdash n}\,E\Box^{\downarrow}$$

Now that we have the morphological information explicit in the structure, we can operate on it. For example, as Heylen showed, it is fairly straightforward to allow for underspecification. The basic idea there is that we introduce structural rules that enable us to rewrite the name of a unary modal operator into another name, in the appropriate context as specified by the structural rule. For example, consider $\Box^{\downarrow}{}_{number}$ as meaning that the type is underspecified for *number* - i.e. the token can be interpreted as being either singular or plural. The token "sheep" is an example in case - $\Box^{\downarrow}{}_{number}n$ means that "sheep" is a noun, either plural or singular. Then, structural rules like the following can be used to specify the underspecified feature to either singular or plural (the $\Diamond$'s correspond to the angular brackets $\langle\cdot\rangle$ in the structure):

(266) a. $[Spec/number, sing]$ $\quad\Diamond_{sing}A \rightarrow \Diamond_{number}A$
b. $[Spec/number, plur]$ $\quad\Diamond_{plur}A \rightarrow \Diamond_{number}A$

Using the first rule, we can for example infer:

(267) $$\dfrac{\dfrac{sheep \vdash \Box^{\downarrow}{}_{number} n}{\langle sheep \rangle^{number} \vdash n}\, E\Box^{\downarrow}}{\langle sheep \rangle^{sing} \vdash n}\, [Spec/number, sing]$$

Note that if we would continue the proof with a $I\Box^{\downarrow}$ step, we could derive the type $\Box^{\downarrow}{}_{sing} n$ for "sheep". Hence, one of the nice advantages of this kind of underspecification is that it enables us to introduce lexical generalizations. Rather than having separate lexical entries for "sheep" as a singular noun, and "sheep" as a plural noun, we can have just one lexical entry defining "sheep" as a noun that is underspecified for number.

Naturally, we should be able to model more complex cases as well. For example, consider the Czech "knihy". This form's case and number are ambiguous between genitive singular, or plural with either nominative or accusative. A category for "knihy" would thus have both the *num* and *case* features underspecified (e.g. $\Box^{\downarrow}{}_{fem}\Box^{\downarrow}{}_{num}\Box^{\downarrow}{}_{case}N$). Subsequently, we would need structural rules that specify e.g. tuples of features rather than single features, like in (268).

(268) $$\begin{array}{lcl} \langle\langle \mathrm{A} \rangle^{sing}\rangle^{gen} & \rightarrow & \langle\langle \mathrm{A} \rangle^{num}\rangle^{case} \\ \langle\langle \mathrm{A} \rangle^{plur}\rangle^{nom} & \rightarrow & \langle\langle \mathrm{A} \rangle^{num}\rangle^{case} \\ \langle\langle \mathrm{A} \rangle^{plur}\rangle^{acc} & \rightarrow & \langle\langle \mathrm{A} \rangle^{num}\rangle^{case} \end{array}$$

A proper consideration of such more complex cases is presented in (Heylen, 1999)(Ch.8), where Heylen discusses sortal hierarchies that control the specification of feature structures.

The way agreement is modeled mimics, in a way, agreement by unification.[11] Namely, the idea is that a composite structure can be "assigned" a feature f if and only if both of its components have that feature f as well. Thus, an abstract structural rule for agreement (concord) would look something like this, in Heylen's theory:

(269) $$\Diamond_f(A \circ B) \rightarrow \Diamond_f A \circ \Diamond_f B$$

In DGL, where we consider headedness as an inherent aspect of composition, I employ slightly different abstract structural rules for handling

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[11] Although we should hasten to say that the model is inherently more powerful than the way morphological information is done in HPSG or feature logics in general, and that we are not doing unification. See also below.

agreement in general:[12]

(270) a. $\Diamond_f(A \circ_{\prec} B) \rightarrow \Diamond_f A \circ_{\prec} \Diamond_f B$

b. $\Diamond_f(A \circ_{\succ} B) \rightarrow \Diamond_f A \circ_{\succ} \Diamond_f B$

Let us consider an example. Take the lexical entry *eat* $\vdash \Box^{\downarrow}{}_{plur}(n \backslash_{\prec} s)$, and try to prove that "Sheep eat" is a sentence with a verbal head that is plural. For agreement (plural) we use the following structural rule:

(271) $\Diamond_{plur}(A \circ_{\prec} B) \rightarrow \Diamond_{plur} A \circ_{\prec} \Diamond_{plur} B$

(272)
$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\mathit{sheep} \vdash \Box^{\downarrow}{}_{num} n}{\langle \mathit{sheep}\rangle^{num} \vdash n}\,E\Box^{\downarrow}}{\langle \mathit{sheep}\rangle^{plur} \vdash n}\,[Spec/number, plur] \quad \dfrac{\mathit{eat} \vdash \Box^{\downarrow}{}_{plur}(np \backslash_{\prec} s)}{\langle \mathit{eat}\rangle^{plur} \vdash (n \backslash_{\prec} s)}\,E\Box^{\downarrow}}{\langle \mathit{sheep}\rangle^{plur} \circ_{\prec} \langle \mathit{eat}\rangle^{plur} \vdash s}\,E\backslash}{\langle \mathit{sheep} \circ_{\prec} \mathit{eat}\rangle^{plur} \vdash s}\,Agr/plur, \prec}{\mathit{sheep} \circ_{\prec} \mathit{eat} \vdash \Box^{\downarrow}{}_{plur} s}\,I\Box^{\downarrow}$$

There is an important observation that we have to make about the proof in (272). As said, we tried to prove $\Box^{\downarrow}{}_{plur} s$ - our "goal type". The observation concerns how the $\Box^{\downarrow}{}_{plur}$ in the goal type actually *enforces* the agreement. For that we should read the proof in a bottom-up way. The goal type is obtained by introducing the $\Box^{\downarrow}{}_{plur}$, which is only possible if the entire structure indeed carries the corresponding diamond (i.e. $\langle \cdot \rangle^{plur}$). For *that* to be possible, the agreement rule posits that both components of the structure have to be decorated with that diamond - thus, both "sheep" and "eat" have to be labeled as plural (*plur*). Which they are - "eat" by lexical assignment, "sheep" by specification of an underspecified feature assignment (*number*). In other words, subject and verb agree, and all is well indeed. But note what would have happened if we would have had a subject in singular. Going bottom-up, the agreement rule would have posited there being a subject in plural, whereas from the lexical entry for the subject we would have obtained singular case (top-down). This clash would have resulted in the proof falling through - we would not be able to derive the goal type.[13]

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[12] The rules in (270) do not intend to cover specific secondary cases such as the remainders of the Dual in Russian, or **Czech** "kotě a štěně si hrály" instead of "hrála".

[13] Unless, of course, we would have the more complex cases of coordinated, singular subjects - as these would lead to a plural construction.

The model so far is as Heylen discussed it his dissertation (Heylen, 1999) and various papers, for example (Heylen, 1997). In (Kruijff, 1998) I introduced an "extension" to Heylen's model, in the form of "a-symmetric distribution rules". Heylen's agreement rules, as we saw them above, are essentially rules that symmetrically distribute a label $\langle\cdot\rangle^f$ from a construction over its two components. However, when one applies Heylen's model to morphologically rich languages, it quickly becomes apparent that we need different kinds of structural rules to manage feature information - not only symmetric distribution rules defining agreement. Because, it may very well happen that a component carries more labels than are needed for a particular type of agreement. For example, a verb may carry information about *tense*, which is information not relevant to agreement with its subject. This leads to structural rules that allow labels to percolate upwards: if a head has a feature f that is not relevant for agreement, then we can percolate that feature upwards, distributing it over the entire composition. These rules are thus a-symmetric in that only one component will be required to have some appropriate labeling, not both components.[14]

As a matter of fact, even though percolation rules are straightforward to specify in categorial type logics (and DGL), they present an important linguistic generalization (together with the way agreement is handled) that feature logics as employed in HPSG are not capable of capturing (Oliva, p.c.). Namely, for unification to work, each feature used in a particular type of agreement needs to be listed explicitly in the attribute-value matrix. This can easily lead to doubling of information about morphological information, and to ensure "consistency" the attribute/value pairs are co-indexed to indicate that the values should be identical. But this is not particularly satisfying - it seems counterintuitive to have to specify various attributes a in one and the same lexical entry. Our approach to handling morphological (featural) information by means of symmetric agreement rules and a-symmetric percolation rules leads to a much more intuitive picture: Specify the information once, and only once. We can do so because we are rewriting, rather than using unification.

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[14] Note that they are similar to the $K1/K2$ rules defined in (Moortgat, 1997).

Morphological strategies: Adposition

Finally, let us discuss adposition. As we already mentioned above, we understand by adposition the use of function words to indicate what morphological category a wordform realizes. Examples of such function words are mentioned in (273).

(273) a. *Prepositions*:
  - i. **English**
    "to" (+N, dative), "of" (+N, genitive)
  - ii. **Dutch** "voor"/"aan" (+N, dative), "van" (genitive)

  b. *Postpositions*:
  - i. **Japanese** "-ga" (+N, nominative), "-o" (+N, accusative)
  - ii. **Korean** "-ka" (+N, nominative), "-lul" (+N, accusative)

Again, the approach to modeling these phenomena in DGL is relatively straightforward. We distinguish modes *post* $\succ, \prec$ *prep* for composition between the noun and its postposition or a preposition, respectively. Example (274) illustrates the prototypical categories for prepositions and postpositions, respectively.

(274) a. *Preposition* corresponding to case C : $\Box^{\downarrow}{}_{C}N/_{prep}N$

b. *Postposition* corresponding to case C : $\Box^{\downarrow}{}_{C}N\backslash_{post}N$

Analyzing a combination of strategies

Although we can model each of the *different* morphological strategies, how would they cooperate in an analysis of a sentence in which various morphological strategies are used at the same time? For example, consider the sentence in (275).

(275) **English**
Elijah reads Christopher's book to Kathy.

The sentence in (275) illustrates three strategies: positioning (Elijah, book), linking (Christopher's), and adposition (to Kathy). For a proof for (275), the most illustrative steps in this context are given in (276) below.

(276) a.

$$\dfrac{\dfrac{\dfrac{\dfrac{\mathit{Elijah} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} N}{\langle \mathit{Elijah}\rangle^{case} \vdash \Diamond_{\delta} N}\,[E\Box^{\downarrow}]}{\langle \mathit{nom}\rangle^{nom} \vdash \Diamond_{\delta} N}\,\mathit{Spec} \qquad \dfrac{\dfrac{[\gamma \vdash N]^{\mathit{2}}}{\langle\gamma\rangle^{Actor} \vdash \Diamond_{Actor} N}\,[I\Diamond] \qquad [\mathrm{r}_{\mathit{0}} \vdash \Box^{\downarrow}{}_{act} n \backslash_{<sc} s]^{\mathit{1}}}{\langle\gamma\rangle^{Actor} \circ_{\prec sc} r \vdash S}\,[E\backslash]}{\langle \mathit{Elijah}\rangle^{nom} \circ_{\prec sc} r \vdash S}\,[E\Diamond]}{\langle \mathit{Elijah}\rangle^{nom} \vdash \Diamond_{Actor} N /_{\prec sc} (\Diamond_{Actor} N \backslash_{\prec sc} S)}\,[I/]^{\mathit{1}}}{\mathit{Elijah} \vdash \Box^{\downarrow}{}_{nom} (\Diamond_{Actor} N /_{\prec sc} (\Diamond_{Actor} N \backslash_{\prec sc} S))}\,[I\Box^{\downarrow}]$$

b.

$$\dfrac{\dfrac{\text{chris} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} n \qquad \text{`s} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} n \backslash_{link>} (\Box^{\downarrow}{}_{case}\Diamond_{\delta} n /_{<adj} \Box^{\downarrow}{}_{case}\Diamond_{\delta} n)}{\text{chris} \circ_{link>} \text{`s} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} n /_{<adj} \Box^{\downarrow}{}_{case}\Diamond_{\delta} n}\,[\backslash E] \qquad \text{book} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} n}{(\text{chris} \circ_{link>} \text{`s}) \circ_{<adj} \text{book} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} n}\,[/E]$$

c.

$$\dfrac{\text{to} \vdash \Box^{\downarrow}{}_{dat}\Diamond_{Addressee} n /_{<prep} \Box^{\downarrow}{}_{case}\Diamond_{\delta} n \qquad \text{kathy} \vdash \Box^{\downarrow}{}_{case}\Diamond_{\delta} n}{\text{to} \circ_{<prep} \text{kathy} \vdash \Box^{\downarrow}{}_{dat}\Diamond_{Addressee} n}\,[/E]$$

4.3.2 DGL's LINKING THEORY

Let me begin by addressing the issue of a linking theory in more detail. One important aspect of the account I give here is that it overcomes the kind of criticism that has been levied both against approaches within dependency grammar (like Fillmore's - cf. (Panevová, 1974; Sgall et al., 1986)), and against similar approaches based on specifying semantics in terms of θ-frames (cf. Davis's dissertation (1996), and references therein to discussions by Wechsler and Dowty). These criticisms all come down to there being no obvious relation between lexical meaning and form (or syntactic behavior). Put differently, the meaning is rendered stipulative at least from the viewpoint of there being no relation between different syntactic behavior (form) and a differentiation in meaning.

This criticism is overcome in DGL by realizing the relation between form and function *as mediated by* morphological categories, a relation that has been pointed out and elaborated within the Prague School of Linguistics ever since the early 1930's. The reason why we indeed overcome the criticism, rather than replace it by another stipulative account, is simple. Morphological categories present a cross-linguistic generalization of the intuitive relation between function and abstract form, and they can be straightforwardly related to the morphological strategies of a *particular* language. This means that morphological categories not only capture intuitions about languages investigated by various members of the Prague school (notably, Slavonic languages, Germanic languages, English) - because they are *abstract* and present cross-linguistic generalizations, they also make predictions about languages that have *not* been investigated from this point of view. The prediction is that, if we couple the morphological strategies of a "new" language to the morphological categories, then we expect the same intuitions about the relation between form and function to be verified (i.e. the morphological strategies help realize the same primary and secondary functions of the morphological category as observed in other languages). Rather than being stipulative, the account is *verifiable* - cross-linguistically, even though the repertoires of categories may differ from one language to another.[15]

To formulate a linking theory for DGL, I start from the basic approach advocated by categorial type logics. Categorial type logic provides a fairly straightforward model of lexical semantics. The semantic λ-term of a word is related to a syntactic type using a *Curry-Howard correspondence* (cf. for example Oehrle's articles (1994; 1995)). A suitable name for this kind of model of lexical semantics would be *logical lexical semantics*, which may be understood as trying to explain the relation between form and function/meaning in a logical way.

According to some authors, the Curry-Howard correspondence in categorial type logic should take the form of an isomorphism. That way categorial type logic would answer a mathematical-logical ideal. Thus, according to Oehrle's (1994), syntactic categories and typed λ-terms are related as per Definition 13.

Definition 13 (Categories and semantic types in CTL). *Given a mapping that relates basic categories $\beta \in \mathcal{B}$ with a corresponding type typβ in a typed λ-calculus. The association between the full set of categories, built using the category-formation operators $\{\backslash_\mu, /_\mu, \circ_\mu\}$, and semantic types can then be defined as follows:*

- *associate each implicational type with argument A and resulting category B (like $B/_\mu A, B\backslash_\mu A$) with the λ-type typ$(A) \rightarrow$ typ(B), i.e. functions from typ(A) to typ(B);*
- *associate the product type with first projection A and second projection B with the pairing of typ(A) and typ(B)*

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[15] With that, the present approach presents an account of the relation between form and function that is more fundamental than for example Wechsler's approach, which does not appear to lend itself well to cross-linguistic generalizations.

See also Hepple's (1994; 1995), and Moortgat's (1997). ⊛

However, I would like to argue that an isomorphic mapping between syntactic types and λ-types does not appear to be desirable from a linguistic viewpoint.[16] Because, if there were to exist an isomorphism between arguments that are obligatory from the viewpoint of proper "grammatical use", and arguments that are obligatory from the viewpoint of meaning (determining "inferrable information" or something similar), then every syntactic argument should be reflected in the semantics, and vice versa. This need not be true, in either direction.

Expletive pronouns In various languages there are verbs that require an expletive pronoun to function as surface subject. A nice example is the German verb "geben", which requires an expletive pronoun "es" to form a sentence like "Es gibt einen Student im Kino" (*En.* "There is a student in the cinema"). Now, if we would indeed have an isomorphism between the syntactic type of "geben" and its λ-term, we would have an argument position in the λ-term for the expletive pronoun as well, which should be filled by whatever semantics we would assign to the expletive pronoun. But, linguistically speaking, this seems counter-intuitive. The expletive pronoun is needed to form a grammatical sentence - but semantically, the expletive can be argued to be vacuous (cf. the discussion in Sgall *et al.* (1986) about function words, and also other approaches where expletives are considered to make no real contribution to the meaning of sentences - cf. HPSG (Pollard and Sag, 1993), (combinatory) categorial grammar (Jacobson, 1990)).

Oehrle pointed out (p.c.) that one could perhaps argue for an argument slot for the expletive pronoun if the pronoun were understood as referring to the larger situation in which the event is placed. Erteshik-Shir does

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[16] Even though what we argue for results in a loss of the isomorphism between syntactic types and λ-types (or formulas and types in the general logical setting), we need not lose the possibility to obtain an isomorphism between proofs and λ-terms. The essential idea behind the Curry-Howard isomorphism is that, due to the isomorphism between formulas and types, we can also obtain an isomorphism between a proof of a formula and a typed term. The latter isomorphism gives rise to the possibility of reconstructing the λ-term once given the proof, and vice versa, given the λ-term, we can reconstruct the proof. It appears to me that, despite the loss of an isomorphism between formulas and types, we can still obtain the isomorphism between proofs and λ-terms, by:

- adding information to the λ-term, recording explicitly each step that is taken; and,
- requiring that the axioms we begin with (or reason backwards to) are identifiable lexical items.

in fact present such an approach, based on a very literal interpretation of Heim's file-change metaphor. However, given the approach we take here to specifying meaning, then each verb can be given an interpretation relative to world-time pairs. In other words, as an eventuality set in a specific time and place. Trying to understand the expletive pronoun as establishing that given again seems to be redundant, then.

Relational nouns One need not only consider the isomorphism in the direction from syntactic type to λ-type. An example showing why there need not be an isomorphism from λ-type to syntactic type is provided by *relational nouns*. These nouns have semantic arguments and yet need not to subcategorize in order to be used grammatically (cf. (Sgall et al., 1986)). Consider the noun "brother", which has as its semantics $brother(x)$ with (at least) the necessary argument *brother-of*(x, y), i.e. $\lambda x\lambda y.(brother(x) \wedge brother - of(x, y)$. Paraphrased, whenever a person x is a brother, he is necessarily a brother of some other person y, $x \neq y$; one could extend this by saying that x is also a son of z, with $x \neq y \neq z$. But the syntactic type of "brother" does not need to subcategorize for a syntactic type corresponding to the argument y, or z, in order for "brother" to be used grammatically. As Sgall *et al.* (1986) point out, the extra argument y is there because in the discourse context it should be answerable who x is a brother of. One cannot sensibly utter that "John is a brother" (understanding brother in the family-sense) without being able to answer the question "Who is John a brother of?", as per the dialogue test.

Raising verbs Finally, various frameworks give an account of raising verbs in which their syntactic type(s) do not correspond isomorphically to their semantic argument structure. This could count as another argument against a strict isomorphism, though this very much depends on one's linguistic intuitions. For example, Jacobson (1990) does give an alternative account of raising using function composition, based on a combinatory form of categorial grammar, and presents evidence for that account.

Thus, the model of lexical semantics that categorial type logic provides us with appears to be too strict to enable us to present particular linguistic intuitions one might have. We need to relax the isomorphism criterion between syntactic types and λ-types in order to be able to capture (at least) the cases we mentioned above.[17] DGL's linking theory is defined as follows.

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[17] As a matter of fact, on the dependency grammar point of view *all* function words

Definition 14 (DGL's linking theory). *Given a mapping* B *between basic categories* β *and the sorts used for specifying lexical meaning (e.g. objects and various kinds of eventualities), a mapping* M *between morphological categories and kinds of dependency relations (i.e. the morphological categories' primary and secondary functions), and a mapping* S *between morphological categories and morphological strategies.*

1. *Given a predicate-valency structure for an eventuality, of the form*

$$(\mathcal{E} \ \wedge \ \pi_{\varepsilon} \ \wedge \langle \delta_{1} \rangle (n_{1}) \wedge \cdots \wedge \langle \delta_i \rangle (n_i)),$$

   specifying the obligatory arguments for π. *The syntactic category corresponding to this predicate-valency structure is built as follows.*

   First, the resulting category is a basic category ρ, *mapped by* B *from the eventuality in* $\mathcal{E}$. *Set the predicate-valency structure's category* Ξ *to* ρ. *Then, going from left to right through the conjunction, for each argument* $\langle \delta_k \rangle (n_k)$, *we use* B *to map the sort of the nominal* n_k *to a category* κ. *Then, we also extend* Ξ *with* $\Xi /_{\mu} \Diamond_{\delta_k} \kappa$ *or* $Xi \backslash_{\mu} \Diamond_{\delta_k} \kappa$, *depending on (a) canonical surface ordering, and (b)* S.

2. *Given a predicate-valency structure based on a nominal* ω *that is not an event nucleus, of the form* $(\omega \ \wedge \ \pi_{\omega} \ \wedge \langle \delta_{1} \rangle (1) \wedge \cdots \wedge \langle \delta_j \rangle (n_j))$. *First, the resulting category is a basic category* ρ, *mapped by* B *from* ω. *Set the predicate-valency structure's category* Ξ *to* ρ. *If any of the arguments specified by the predicate-valency structure are required to be mapped to syntactic categories for the word to be used grammatically, then follow the steps outlined above.*

Finally, to express a particular wordform's morphological features like number, gender, or person, Ξ *is prefixed with the appropriate* $\Box^{\downarrow}$*'s.*

Example. To illustrate the above linking theory, let us consider a few simple examples from English and Czech. First, we set up the following mappings. For each mapping we indicate for what language(s) it is applicable.

(277) a. $\mathsf{B}\{\mathbf{Cz,En}\} \begin{cases} n & \text{if object} \\ s & \text{if eventuality} \end{cases}$

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provide a counter example, since they would be modeled (in DGL) as function types but their contribution to linguistic meaning would be phrased entirely differently (if it all).

b. $$\mathsf{M}\{\mathbf{Cz,En}\}\begin{cases} \textit{nom} & \text{if } \mathbf{Actor} \\ \textit{acc} & \text{if } \mathbf{Patient} \\ \textit{dat} & \text{if } \mathbf{Addressee} \end{cases}$$

c. $$\mathsf{S}\{\mathbf{En}\}\begin{cases} \text{first pre-verbal position, } \prec sc & \text{if nom} \\ \text{direct-complement position, } dc \succ & \text{if acc} \\ \text{indirect-complement position, } ic \succ & \text{if dat} \end{cases}$$

$$\mathsf{S}\{\mathbf{Cz}\}\begin{cases} \text{first post-verbal position, } sc \succ & \text{if nom} \\ \mathbf{Actor} < \mathbf{Patient},\ c \succ & \text{if acc} \\ \mathbf{Actor} < \mathbf{Addressee}, \mathbf{Addressee} < \mathbf{Patient},\ c \succ & \text{if dat} \end{cases}$$

d. $$\text{morph.features}\{\mathbf{Cz,En}\}\begin{cases} \Box^{\downarrow}{}_{\mathit{3rd}}\Box^{\downarrow}{}_{\mathit{sing}} & \text{if 3rd person, singular} \\ \Box^{\downarrow}{}_{\mathit{1st}}\Box^{\downarrow}{}_{\mathit{plur}} & \text{if 1st person, plural} \end{cases}$$

Subsequently, consider the following predicate-valency structures in (278).

(278) a. $(\ \mathcal{E}\ \wedge\ \mathit{sleep}\ \wedge\ \langle\textsc{Actor}\rangle(x)\ )$

b. $(\ \mathcal{E}\ \wedge\ \mathit{read}\ \wedge\ \langle\textsc{Actor}\rangle(x)\ \wedge\ \langle\textsc{Patient}\rangle(y)\ )$

(278(a)) translates into the categories given in (279) for English and Czech. The resulting lexical entries are given in (280).

(279) a. **English**: $s\backslash_{\prec sc}\Diamond_{Actor}n$

b. **Czech**: $s/_{sc\succ}\Diamond_{Actor}n$

(280) a. **English**: sleep $\vdash \Box^{\downarrow}{}_{\mathit{1st}}\Box^{\downarrow}{}_{\mathit{plur}}(s\backslash_{\prec sc}\Diamond_{Actor}n)\ :\ (\ \mathcal{E} \wedge \mathit{sleep} \wedge \langle\textsc{Actor}\rangle(x)\ )$

b. **Czech**: spíme $\vdash \Box^{\downarrow}{}_{\mathit{1st}}\Box^{\downarrow}{}_{\mathit{plur}}(s/_{sc\succ}\Diamond_{Actor}n)\ :\ (\ \mathcal{E} \wedge \mathit{sleep} \wedge \langle\textsc{Actor}\rangle(x)\ )$

Similarly, (278(b)) translates into the categories for English and Czech given in (281). The resulting lexical entries are given in (282).

(281) a. **English**: $(s\backslash_{\prec sc}\Diamond_{Actor}n)/_{dc\succ}\Diamond_{Patient}n$

b. **Czech**: $(s/_{c\succ}\Diamond_{Patient}n)/_{sc\succ}\Diamond_{Actor}n$

(282) a. **English**

reads $\vdash \Box^{\downarrow}{}_{\mathit{3rd}}\Box^{\downarrow}{}_{\mathit{sing}}((s\backslash_{\prec sc}\Diamond_{Actor}n)/_{dc\succ}\Diamond_{Patient}n)\ :$
$(\ \mathcal{E}\ \wedge\ \mathit{read}\ \wedge\ \langle\textsc{Actor}\rangle(x)\ \wedge\ \langle\textsc{Patient}\rangle(y)\ )$

b. **Czech**

čte $\vdash \Box^{\downarrow}{}_{\mathit{3rd}}\Box^{\downarrow}{}_{\mathit{sing}}((s/_{c\succ}\Diamond_{Patient}n)/_{sc\succ}\Diamond_{Actor}n)\ :$
$(\ \mathcal{E}\ \wedge\ \mathit{read}\ \wedge\ \langle\textsc{Actor}\rangle(x)\ \wedge\ \langle\textsc{Patient}\rangle(y)\ )$

With the relation between predicate-valency structures and syntactic categories thus established, how do we interpret a wordform as a particular kind of dependent? The answer to this is significantly less involved than the previous discussion, and is based on a discussion I provided in (1999a).

Essentially, what we do is introduce structural rules that enable us to rewrite a modal indicating that a structure realizes a particular a morphological category, to a modal indicating a type of dependency relation which is the primary (or possibly secondary) function of that morphological category. Additionally, function words can be given function categories that have, as the result category, a category indicating a type of dependency relation.

For example, consider the structural rules in (283(a)), and the function words in (283(b)).

(283) a.

$$\langle\langle A\rangle^{nom}\rangle^{Actor} \rightarrow \langle\langle A\rangle^{nom}\rangle^{\delta}$$
$$\langle\langle A\rangle^{acc}\rangle^{Patient} \rightarrow \langle\langle A\rangle^{acc}\rangle^{\delta}$$
$$\langle\langle A\rangle^{dat}\rangle^{Addressee} \rightarrow \langle\langle A\rangle^{dat}\rangle^{\delta}$$

b.

German in $\vdash\ \Box^{\downarrow}{}_{Locative}n/_{prep}\Box^{\downarrow}{}_{dat}n\ :\ @_h\langle\textsc{Locative}\rangle a$

German in $\vdash\ \Box^{\downarrow}{}_{WhereTo}n/_{prep}\Box^{\downarrow}{}_{acc}n\ :\ @_h\langle\textsc{WhereTo}\rangle a$

The function words in (283(b)) lead to complement-categories. Alternatively, if we want to create adjuncts, then we can use the categories as in (284).

(284)

German in $\vdash\ \Diamond_{Locative}(s\backslash_{a\succ}s)/_{prep}\Box^{\downarrow}{}_{dat}n : (@_c\top)$

German in $\vdash\ \Diamond_{WhereTo}(s\backslash_{a\succ}s)/_{prep}\Box^{\downarrow}{}_{acc}n : (@_c\top)$

Example 4.3.3 (page 139ff.) illustrates the use of these German function words in a derivation, after I have presented the entire base logic for DGL.

4.3.3 THE COMPOSITION OF LINGUISTIC MEANING

How do we construct linguistic meaning in DGL? The key idea followed here is to build "syntactic structure and semantic structure in parallel". In the previous section I already discussed how the functional structure of a word's lexical meaning is closely reflected in its syntactical category. Hence, the composition of a sentence's linguistic meaning closely corresponds to how words can be related at the surface.

More precisely, DGL adheres to a principle of *compositionality*, characterized by Partee *et al.* in (1990) as follows:

> "The meaning of a compound expression is a function of the meanings of its parts and of the syntactic rule by which they are combined." (p.318)

Similar principles of compositionality can be found throughout formal grammar and formal semantics - see Janssen's (1997) for a general overview of compositionality principles, Gamut's (1991), Van Benthem's (1991a), and Morrill's (1994) for compositionally relating categorial grammar and Montague's intensional logical semantics.

A difference between DGL and Montague Grammar is though that we make a difference between the *absence* of meaning, and the *absurdity* of meaning. This point dates back to Sgall *et al.*'s discussion in (1986). In Montague's approach, only those trees are considered to be well-formed which can receive an interpretation from a model for that intensional logic being used. In other words, well-formedness equates to meaningfullness, with the latter meaning "interpretable on a model". Sgall *et al.*, when discussing Chomsky's infamous example (285), point out that the sentence *does* have a meaning, and that the sentence definitely is well-formed - despite the fact that the meaning is *absurd*.

(285) Colorless green ideas sleep furiously. (Chomsky, 1957)

Parasitic situations aside, we would normally not consider (285) to make sense - yet the very fact *that* we can make that consideration means that (285) at least has a *linguistic* meaning.[18] On the other hand, (286) does not even have an absurd linguistic meaning, since it is not grammatically well-formed and hence does not even enable us to construct a representation of its linguistic meaning.

(286) **English**
Furiously sleep ideas green colorless.

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[18] We could try to phrase "absurdity of meaning" in transparent intensional logic (Materna, 1998) as the impossibility to conceive of an object that the construction made for the expression that (285) corresponds to. Absence simply means that there is no construction for the expression. For a relation between categorial grammar, dependency grammar, and transparent intensional logic see the brief discussion in (Kruijff, 2000).

In the remainder of this section, I discuss how DGL builds representations of linguistic meaning in a compositional way, and how we explain the mentioned difference between absence and absurdity of linguistic meaning.

Traditionally, categorial type logics use a (typed) λ-calculus for specifying the meaning of a sentence. A convenient mathematical fact thereby is that there is a close correspondence between natural deduction and the λ-calculus - the *Curry-Howard correspondence.* An important result established by the Curry-Howard correspondence is that an elimination rule, eliminating an implication and thereby combining two elements, corresponds to *functional application* in the λ-calculus. Conversely, an introduction rule corresponds to *functional abstraction.* Thus, for example, when we apply an elimination rule to combine a function and an argument, we can *in parallel* apply the meaning of the argument to the meaning of the function (which is traditionally specified as a λ-term).

The issue now is, how can we establish a correspondence between natural deduction and operations in a hybrid logic, so as to compose a representation of a sentence's linguistic meaning in parallel to an analysis of the sentence's form? The answer is relatively simple, in fact.[19] First of all, we should recall that what we are building are *relational* structures. For a head h that means that it may be looking for an argument. That is, $h \wedge @_h\langle\delta\rangle d$, we have a nominal h that refers to some state where the head's proposition holds, and from where we should be able to link to some other (yet unspecified) state d along a δ (dependency) relation. Similarly, once we interpret a word group as a particular type of dependent, we specify that as saying that it is a dependent that is looking for a head. We have something like $@_h\langle\delta\rangle d$, but now δ and d are further specified and it is the h that we need to establish. In other words, to combine a head h with a dependent d, all we need to say is that d is what h is looking for, and vice versa. For example, consider again the lexical assignment for "sleeps", repeated below in (287).

(287) sleeps $\vdash \Box^{\downarrow}{}_{3rd}\Box^{\downarrow}{}_{sing}(s\backslash_{sc}\Diamond_{Actor}n)\ :\ (\ \mathcal{E}\ \wedge\ \mathit{sleep}\ \langle\textsc{Actor}\rangle(x)\ )$

How does it get combined with its **Actor**? The steps are in given (288).

(288) i. $@_h(\mathcal{E}\ \wedge\ \mathbf{sleep}\ \wedge\ \langle\textsc{Actor}\rangle(x)\ )$

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[19] I am very much indebted to Carlos Areces and to Alexander Koller for the discussions that eventually led the calculus I present here.

ii. $@_{h'}\langle\textsc{Actor}\rangle(\ e\ \wedge\ \textbf{Elijah}\ )$

iii. $@_h(\mathcal{E} \wedge \textbf{sleep} \wedge \langle\textsc{Actor}\rangle(x)\ ) \wedge @_{h'}\langle\textsc{Actor}\rangle(\ e \wedge \textbf{Elijah}\ ) \wedge @_h h'$

iv. Axiom: $@_i\langle\textsc{Actor}\rangle j\ \wedge\ @_i\langle\textsc{Actor}\rangle k\ \rightarrow\ @_j k$

v. $@_h(\ \mathcal{E}\ \wedge\ \textbf{sleep}\ \langle\textsc{Actor}\rangle(\ e\ \wedge\ \textbf{Elijah}\ ))$

Because stating that $@_h h'$ means that h and h' refer to the same state, (288v) is model-theoretically equivalent to (288iii) together with the axiom in (288iv). Clearly, this operation is similar to β-normalization.

Conversely, how do we model the analogon of functional abstraction? Functional abstraction corresponds to the application of an introduction rule, which discharges an assumption. For that discharge to work, the assumption must have been used earlier in the derivation. Given the above discussion, this must have lead to the introduction of a *link* (@) between the assumption's 'meaning' and an argument. Discharging the assumption then can be understood as simply severing that link: Formally, we replace the link $@_h x$ between the assumption's nominal h and the argument x by $\top$. Because $A\ \wedge\ \top\ \equiv\ A$, we thus *effectively* drop the assumption.[20]

Definition 15 (Base logic for DGL). *We define the base logic for DGL in terms of the proof calculus of Definition 12 (p.110) to which we add operations acting on representations formulated in a hybrid logic.*

$$\frac{\alpha \vdash A : @_p\Psi \qquad \beta \vdash (B \backslash_\mu A) : @_{p'}\Phi}{(\alpha \circ_\mu \beta) \vdash B : @_{p'}\Phi \wedge @_{p'}\Psi}\ E\backslash_\mu$$

$$\frac{\beta \vdash (B/_\mu A) : @_{p'}\Phi \qquad \alpha \vdash A : @_p\Psi}{(\beta \circ_\mu \alpha) \vdash B : @_{p'}\Phi \wedge @_{p'}\Psi}\ E/_\mu$$

$$\begin{array}{l} [\alpha \vdash A : @_h\top]\cdots \\ \qquad\vdots \\ \qquad \dfrac{(\alpha \circ_\mu \beta) \vdash B : @_{p'}\Phi \wedge @_{p'}\top}{\beta \vdash (B \backslash_\mu A) : @_{p'}\Phi}\ I\backslash_\mu \end{array}$$

$$\begin{array}{r} \cdots[\alpha \vdash A : @_h\top] \\ \vdots\qquad \\ \dfrac{(\beta \circ_\mu \alpha) \vdash B : @_{p'}\Phi \wedge @_{p'}\top}{\beta \vdash (B/_\mu A) : @_{p'}\Phi}\ I/_\mu \end{array}$$

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[20] And, for that reason, we also drop the conjunct.

$$\dfrac{\alpha[(\gamma \bullet_{\mu} \zeta)] \;\vdash\; A : @_{p'}\Phi_{\alpha} \wedge @_{h}\top \wedge @_{h'}\top \qquad \beta \;\vdash\; (B \bullet_{\mu} C) : @_{p"}\Phi_{\beta}}{\alpha[\beta] \;\vdash\; A : @_{p'}\Phi_{\alpha} \wedge @_{p'}\Phi_{\beta}}\; E\bullet_{\mu} \quad \text{with } \begin{array}{c}[\gamma \;\vdash\; B : @_{h}\top] \quad [\zeta \;\vdash\; C : @_{h'}\top]\\ \vdots\end{array}$$

$$\dfrac{\alpha \;\vdash\; A : \Phi_{\alpha} \quad \beta \;\vdash\; B : \Phi_{\beta}}{(\alpha \circ_{\mu} \beta) \;\vdash\; A \bullet_{\mu} B : @_{p'}\Phi_{\alpha} \wedge @_{p"}\Phi_{\beta}}\; I\bullet_{\mu}$$

Note that we have defined the above rules for Steedman-style notation of categories. The rules below define the behavior of unary modals $\Box^{\downarrow}$ *and* $\Diamond$ *that are semantically relevant (Morrill, 1994). Unary modals that are semantically neutral leave the semantics untouched.*

$$\dfrac{\alpha \vdash A : @_{h}\Psi}{\langle\alpha\rangle^{i}{}_{\nu} \vdash \Diamond_{i} A : @_{h}\langle\text{I}\rangle_{\nu}\Psi}\; I\Diamond \qquad \dfrac{\alpha \vdash \Diamond_{i} A : @_{x}\langle\text{I}\rangle\Psi \qquad \begin{array}{c}[\gamma \vdash A : \phi]\\ \vdots\\ \beta[\langle\gamma\rangle^{j}{}_{\nu}] \vdash B : \Phi[\langle\text{J}\rangle_{\nu}\phi]\end{array}}{\beta[\alpha] \vdash B : \Phi[\langle\text{J}\rangle_{\nu}\Psi]}\; E\Diamond$$

$$\dfrac{\langle\alpha\rangle^{i}{}_{\nu} \vdash A : \Gamma[[\text{I}]_{\nu}\Psi]}{\alpha \vdash \Box^{\downarrow}{}_{i} A : \Gamma[[\text{I}]_{\nu}\Psi]}\; I\Box^{\downarrow}{}_{i} \qquad \dfrac{\alpha \vdash \Box^{\downarrow}{}_{i} A : @_{x}[\text{I}]_{\nu}\Psi}{\langle\alpha\rangle^{i}{}_{\nu} \vdash A : @_{x}[\text{I}]_{\nu}\Psi}\; E\Box^{\downarrow}{}_{i}$$

We keep the relations between $\Box^{\downarrow}/\Diamond$ *and* $[\cdot]/\langle\cdot\rangle$ *strictly local. We obtain this by labelling a structural modal with an index* ν *corresponding to the index given to the underlying modal relation. Observe that we allow for a more specific mode* x *to replace a less specific mode* y *in the representation of linguistic meaning in* $E\Diamond$*. In line with this possibility we drop the* ceteris paribus *condition usually assumed for structural rules: If a structural rule changes the mode of a structural modal, then the mode of the underlying modal relation changes accordingly. Finally, note that we do not have term constructors or deconstructors in DGL. They can be considered identity functions, by which we trivially obey the general residuation laws for unary modal operators (Moortgat, 1997).* ⊛

Remark 15 (Putting things together). The elimination rules in Definition 15 bind the head and the dependent as follows. The dependent comes with a reference to a head p, whereas the head is stated at p'. The resulting conjunction states that both the dependent and the head hold at p'. This is an abbreviation that is equivalent to repeating the original formulas and then equating p and p' using $@_p p'$, as done in (288iii).

With that, the point could be raised that on the one hand, I argued that (in a λ-calculus) delayed β-normalization would be favorable over including normalization directly in the calculus, whereas on the other hand it seems that Definition 15 *does* include a form of normalization. Is there a contradiction arising from this?

The answer is, no. The important point is not so much whether or not to delay β-normalization - the point is whether we are able to explain the difference between the absence of linguistic meaning and the absurdity of linguistic meaning. Unlike standard β-normalization, composition as defined in Definition 15 does not fail when incompatible meanings are combined. The reason for this is that we only *state* that something to hold. But, recall that as long as we have not bound the nominals to specific states in a model, that statement is all we have. The difference between absurdity and absence of linguistic meaning (Sgall et al., 1986) is thus maintained. ⊛

Example. On the basis of Definition 15, how can we built the linguistic meaning given in (289) in parallel to an analysis of its surface form?

(289) a. **German**

Christopher geht ins Kino in der Stadt.
Christopher goes into-the cinema in the city

"Christopher goes to the cinema in the city."

b. $(\mathcal{E} \wedge \mathbf{go} \wedge \langle \textsc{Actor} \rangle (c \wedge \mathbf{Christopher}) \wedge \langle \textsc{Dir:Where\ To} \rangle (k \wedge \mathbf{cinema})$
$\wedge \langle \textsc{Locative} \rangle (s \wedge \mathbf{city}))$

The proof in (290) shows how to employ the calculus of Definition 15 and relevant structural rules to analyze the sentence's surface form, and build a representation of its linguistic meaning.[21]

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[21] Because I have not dealt with information structure yet, I do not specify any semantic import for determiners in (290).

(290)

$$\begin{array}{lll}
1. & \text{Lex} & in \vdash \Diamond_{whereto} n /_{\prec prep} \Box^{\downarrow}{}_{acc} \Diamond_{\delta} n : @_x(@_x h \ \wedge \ @_h \langle \textsc{WhereTo} \rangle n) \\
2. & \text{Lex} & das \vdash \Box^{\downarrow}{}_{acc} \Diamond_{\delta} n /_{\prec det} \Box^{\downarrow}{}_{case} \Diamond_{\delta} n : @_f \top \\
3. & \text{Lex} & Kino \vdash \Box^{\downarrow}{}_{case} \Diamond_{\delta} n : @_y \langle \delta \rangle (k \ \wedge \ \mathbf{cinema}) \\
4. & \text{E}/(2,3) & (das \circ_{\prec det} Kino) \vdash \Box^{\downarrow}{}_{acc} \Diamond_{\delta} n : @_y \langle \delta \rangle (k \ \wedge \ \mathbf{cinema}) \\
5. & \text{E}/(4,5) & (in \circ_{\prec prep} (das \circ_{\prec det} Kino)) \vdash @_h \langle \textsc{WhereTo} \rangle (k \ \wedge \ \mathbf{cinema}) \\
6. & \text{Lex} & geht \vdash (S \backslash_{\prec sc} \Diamond_{Actor} n) /_{c \succ} \Diamond_{WhereTo} n : @_g((\mathcal{E} \ \wedge \ \mathbf{go}) \ \wedge \ \langle \textsc{Actor} \rangle a \ \wedge \ \langle \textsc{WhereTo} \rangle w) \\
7. & \text{Lex} & Christopher \vdash \Box^{\downarrow}{}_{nom} \Diamond_{\delta} n : @_h(c \ \wedge \mathbf{chris}) \\
8. & \text{E}\Box^{\downarrow}(7) & \langle Christopher \rangle^{nom} \vdash \Diamond_{\delta} n : @_h(c \ \wedge \mathbf{chris}) \\
9. & \text{Hyp} & X \vdash N \\
10. & \text{I}\Diamond(9) & \langle \text{X} \rangle^{Actor} \vdash \Diamond_{Actor} N \\
11. & \text{E}/(6,5) & geht \circ_{c \succ} (in \circ_{\prec prep} (das \circ_{\prec det} Kino)) \vdash (S \backslash_{\prec sc} \Diamond_{Actor} n) : \\
 & & @_g((\mathcal{E} \ \wedge \ \mathbf{go}) \ \wedge \ \langle \textsc{Actor} \rangle a \ \wedge \ \langle \textsc{WhereTo} \rangle (k \ \wedge \ \mathbf{cinema})) \\
12. & \text{E}\backslash(11,10) & X \circ_{\prec sc} (geht \circ_{c \succ} (in \circ_{\prec prep} (das \circ_{\prec det} Kino))) \vdash S : \\
 & & @_g((\mathcal{E} \ \wedge \ \mathbf{go}) \ \wedge \ \langle \textsc{Actor} \rangle a \ \wedge \ \langle \textsc{WhereTo} \rangle (k \ \wedge \ \mathbf{cinema})) \\
13. & \text{E}\Diamond(12,8) & \langle Christopher \rangle^{nom} \circ_{\prec sc} (geht \circ_{c \succ} (in \circ_{\prec prep} (das \circ_{\prec det} Kino))) \vdash S : \\
 & & @_g((\mathcal{E} \ \wedge \ \mathbf{go}) \ \wedge \ \langle \textsc{Actor} \rangle (c \ \wedge \mathbf{chris}) \ \wedge \ \langle \textsc{WhereTo} \rangle (k \ \wedge \ \mathbf{cinema})) \\
14. & \text{Lex} & in \vdash (S \backslash_{a \succ} S) /_{\prec prep} \Box^{\downarrow}{}_{dat} \Diamond_{\delta} n : \\
 & & @_{h'}(@_{h'} x \ \wedge \ @_x \langle \textsc{Locative} \rangle n) \\
15. & \text{Lex} & der \vdash \Box^{\downarrow}{}_{dat} \Diamond_{\delta} n /_{\prec det} \Box^{\downarrow}{}_{case} \Diamond_{\delta} n : @_a \top \\
16. & \text{Lex} & Stadt \vdash \Box^{\downarrow}{}_{case} \Diamond_{\delta} n : @_h \langle \delta \rangle (s \ \wedge \ \mathbf{city}) \\
17. & \text{E}/(15,16) & (der \circ_{\prec det} Stadt) \vdash \Box^{\downarrow}{}_{dat} \Diamond_{\delta} n : @_h \langle \delta \rangle (s \ \wedge \ \mathbf{city}) \\
18. & \text{E}/(14,17) & (in \circ_{\prec prep} (der \circ_{\prec det} Stadt)) \vdash (S \backslash_{a \succ} S) : @_x \langle \textsc{Locative} \rangle (s \ \wedge \ \mathbf{city}) \\
19. & \text{E}\backslash(18,13) & (((\langle Christopher \rangle^{nom} \circ_{\prec sc} (geht \circ_{c \succ} (in \circ_{\prec prep} (das \circ_{\prec det} Kino)))) \circ_{\prec a} (in \circ_{\prec prep} (der \circ_{\prec det} Stadt))) \vdash S : \\
 & & @_g((\mathcal{E} \ \wedge \ \mathbf{go}) \ \wedge \ \langle \textsc{Actor} \rangle (c \ \wedge \mathbf{chris}) \ \wedge \ \langle \textsc{WhereTo} \rangle (k \ \wedge \ \mathbf{cinema}) \\
 & & \ \wedge \ \langle \textsc{Locative} \rangle (s \ \wedge \ \mathbf{city}))
\end{array}$$

4.4 TYPOLOGY, FORM, AND STRUCTURAL RULES

The idea I want to explore here is how to build *multilingual* grammar fragments, i.e. fragments describing phenomena of more than one language, by distinguishing in what language(s) a particular structural rule is applicable.

The approach that I take here with DGL is of course not entirely unique. There have been previous attempts at combining formal approaches to grammar (or rather, to *syntax pure*) and a typological perspective. One approach was instigated by Chomsky in (1965), and focused on constructing a "Universal Grammar" that would arguably underly every existing human language. A fundamental problem with that approach was that the Universal Grammar was thought to be construable by studying just a single language – English. This naturally led to the criticism that typological universals cannot be defined on the basis of the results obtained from a single language. Later, approaches shifted their emphasis to variation. The *Principles and Parameters* generative grammar framework, proposed by Chomsky in the early 1980's, defines parameters on variation. The collective possibilities of how to set these parameters define "the" possible grammars - and, stronger, the possible human languages. Another approach is Jackendoff's X-bar theory (1977). What the above approaches thus have more or less in common is that they start from a single language, and describe possible variation in the build-up of grammars in terms of the observations done on that language. This is not the approach I take here. Rather, the attempts I make here should be placed in a paradigm that could (loosely) be called "typological universal grammar", as advanced by people like Greenberg, Keenan, Comrie, and Hawkins, and which -at times- has had close ties with categorial grammar. The starting point of this paradigm is that languages *differ*, and that the task is to characterize the regularities in that variation. As this type of variation can be more conveniently captured by a head-dependent asymmetry distinction than the strictly linear character of phrase-structure grammars (cf. (Hawkins, 1983)), it should come perhaps as no surprise that the above perspective on cross-linguistic modeling has been tried before in *categorial* formal grammars. Venneman proposed around two decades ago an approach based on a categorial grammar formalism that included a head-dependent asymmetry (cf. (Venneman, 1977; Hawkins, 1983)), and Steedman's CCG provides an account of cross-linguistic variation (in Germanic languages) in terms of availability of specific combinatory rules (1996; 2000c). It is this 'tradition' that I try to continue with DGL, combining it with insights from Praguian views on typology and the system of language as such.

Technically, if we restrict each rule to being applicable in one language only, we obtain a "hybrid" fragment that is simply a set of structural rules, for several languages, that do not interact at all. This is one sense in which we can understand multilinguality of resources: We have a collection of separate, language-specific resources. However, if we allow a structural rule to be applicable in *various* languages, we get a much more interesting perspective. If a structural rule, describing form, is applicable in several languages then that rule can be understood to indicate what these languages have *in* *common*, whereas a structural rule applicable in only one language indicates how that language *differs* from all the rest. This is the sense of multilinguality I am interested in here: merged resources, where models for different languages may share particular fragments. (See also (Kruijff et al., 2000).)

The important point here is that multilingual grammar fragments enable one to construct a *typological perspective* of *cross-linguistic comparison* (cf. (Croft, 1990), Ch.1). Arguably, it is *necessary* for a framework to be able to provide this perspective: Only through application of a given grammar framework to modelling a variety of languages the framework can be validated. Modelling phenomena *cross-linguistically* elucidates whether a framework's mechanisms are indeed general enough to be able to be specific enough.

DGL, and categorial type logic, provide a setting in which we can achieve this. We *assume* that the base logic, defined earlier, is language universal. Thus, we conjecture that we can build models for all natural language grammars that start from this common basis, defining the relation between form and meaning in a compositional way, to which we can add structural rules defining more elaborate means of structural control and structural relaxation.[22] Below, we propose to model of cross-linguistic variation and similarity as networks of structural rules.

4.4.1 Structural rules and gradual refinement

According to Halliday, a grammar is "a theory about language as a resource for making meaning" (1985)(p.xxvi). Halliday (1985) proposes to build up a grammar from *systems*, organized in *networks* that are stratified by *ranks*. A system models a particular choice, driven by the meaning we want to convey. Descending down the ranks, the choices made by the systems inhabiting these lower ranks become successively more specific, dealing with increasingly finer detail. To relate this to grammatical structure, systems at a higher rank deal with general organization of a sentence, e.g. type of speech act, clause-complexity, choice of mood and voice. Systems at a lower rank decide about more specific detail. Next to the notion of ranks Halliday

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[22] It should be noted that the claim concerns here the *possibility to model* grammars that way. We are by no means claiming that *natural language grammars* all work that way from a *cognitive* point of view. Such a perspective is hardly warranted by, and goes beyond, mathematical modeling.

considers the notion of *delicacy.* By the delicacy of a system, or group of systems, we understand the relative generality of the decision a system makes. A lower delicacy means that it is more general than a high delicacy choice, and as such there is some hope that it holds for more languages - though this is, of course, an empirical matter. Under a non-standard interpretation (Bateman,p.c.) one can also consider the use of a syntagmatic notion of delicacy: that is having grammatical constituents described in more or less detail. With this, we get an analogy between rank and delicacy: The higher the rank, the lower the delicacy.

How can we translate this picture to categorial type logics? As far as I am aware of, cross-linguistic modelling (in the above sense) has never been discussed in categorial type logics, only -to some extent- in CCG (cf. (Steedman, 2000c; Kruijff and Baldridge, 2000)). Here, I propose to represent a set of structural rules as a *network.* We can *annotate* each structural rule (or package of structural rules) with the language(s) for which it holds. Following the ideas of ranking and delicacy, structural rules of higher ranking express commonalities among languages (if the set is multilingual), and lower ranking expresses differentiation.

4.4.2 MULTILINGUAL NETWORKS OF STRUCTURAL RULES

In the current section I discuss how we can build multilingual networks of structural rules. (Part II contains numerous examples of such networks.)

As is customary in categorial type logic, each structural rule in a fragment is given a *name* - be that something like the rather nondescriptive $[Px]$ or a more elaborate name like $[Head - Wrapping]$. Given a name $[\Upsilon]$ for a structural rule $\Gamma \rightarrow \Gamma'$, we generally write $[\Upsilon]\ \Gamma \rightarrow \Gamma'$. We extend that representation here with a set Θ indicating the *languages* to which the structural rule is applicable - i.e. the structural rule is understood to model part of a phenomenon in a way that is appropriate for the language(s) listed in Θ. For example, if $[\Upsilon]$ is applicable to languages $\{\theta_i, \theta_j\}$, then we write this as in (291).

(291) $[\Upsilon]_{\{\theta_i,\theta_j\}}\ \Gamma \rightarrow \Gamma'$

Model-theoretically, this change to the representation has little or no impact: We are merely claiming that $[\Upsilon]$ is modelled by the appropriate frame-conditions both in the model $\mathfrak{M}_{\theta_i}$ for language θ_i, and in the model $\mathfrak{M}_{\theta_j}$ for θ_j.[23]

Given a set of structural rules, each annotated for the language(s) they are applicable to, how do we organize them into a *network*? The organizing principles are laid down in Definition 16.

Definition 16 (Architectures: Multilingual networks of structural rules). *Given a set of structural rules, $\mathcal{S} = \{\rho_1, ..., \rho_n\}$, whereby each structural rule is of the form $[\Upsilon]_\Theta\ \Gamma \to \Gamma'$. We say that two rules ρ_i and ρ_j are connected in the network, $\mathfrak{N}$, with ρ_i* dominating *ρ_j (written as $\rho_i \rhd \rho_j$), iff:*

i. $|\Theta_{\rho_i}| \supseteq |\Theta_{\rho_j}|$*, i.e. ρ_i is applicable to at least as many languages as ρ_j.*

ii. The output structure of ρ_i serves as an input structure to ρ_j, i.e if $\rho_i \equiv \Gamma \to \Gamma'$ then $\rho_j \equiv \Gamma'' \to \Gamma$.

A connected path π between a structural rule ρ_i and ρ_k is defined as the non-reflexive transitive closure over $\rhd$. The existence of a path π between ρ_i and ρ_k is written as $\rho_i \overset{\pi}{\rhd} \rho_k$. The set of language(s) *that a path covers is defined as the set of languages of ρ_k.*

Finally, to ensure that a network is always fully connected, we add a Start *node. This node does not correspond to a structural rule. It only indicates the top of the network. By definition it dominates every node, and there always exists a path between* Start *and every rule in the given set of structural rules.* $\circledast$

To illustrate Definition 16, I end this section with two (abstract) examples. In the next Part I discuss a more elaborate linguistic examples, mostly involving word order.

Example. Consider the set of structural rules in (292), defined for languages θ_1, θ_2.

(292)
$$\mathcal{S}_1 = \left\{ \begin{array}{lrcl} [\Upsilon 1]_{\{\theta_1,\theta_2\}} & \Gamma' & \to & \Gamma, \\ [\Upsilon 2]_{\{\theta_1,\theta_2\}} & \Gamma'' & \to & \Gamma', \\ [\Upsilon 3]_{\{\theta_1\}} & \Gamma^{(3)} & \to & \Gamma'', \\ [\Upsilon 4]_{\{\theta_2\}} & \Gamma^{(4)} & \to & \Gamma'' \end{array} \right\}$$

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[23] We do not explore here the (purely technical) question whether we could generate a combined model for a set of languages Θ, $\mathfrak{M}_\Theta$, in which ranking could for example relate to a hierarchy of filters as discussed in (Kurtonina, 1995).

Clearly, we have the following relations: $\Upsilon 1 \rhd \Upsilon 2$, $\Upsilon 2 \rhd \Upsilon 3$, $\Upsilon 2 \rhd \Upsilon 4$. Thus, we can depict the network as a tree, as in Figure 4.4.2 below.

[treefit=tight,levelsep=6ex] Start $[\Upsilon 1]_{\{\theta_1,\theta_2\}}$ $[\Upsilon 2]_{\{\theta_1,\theta_2\}}$ $[\Upsilon 3]_{\{\theta_1\}}$ $[\Upsilon 4]_{\{\theta_2\}}$

Figure 4.3: A simple multilingual network of structural rules

Furthermore, the language θ_1 is covered by the path $[\Upsilon 1] \overset{\pi}{\rhd} [\Upsilon 3]$, whereas θ_2 is covered by $[\Upsilon 1]\ \overset{\pi}{\rhd}\ [\Upsilon 4]$. ⊛

Example. Let us consider what happens when we extend the set $\mathcal{S}_1$ given in (292) with the following set of rules, given in (293)

$$(293) \quad \mathcal{S}_1 = \left\{ \begin{array}{llll} [\Upsilon 5]_{\{\theta_1\}} & \Gamma^{(6)} & \rightarrow & \Gamma^{(5)}, \\ [\Upsilon 6]_{\{\theta_1\}} & \Gamma^{(7)} & \rightarrow & \Gamma^{(6)} \end{array} \right\}$$

We have that $\Upsilon 5 \rhd \Upsilon 6$ but there is no structural rule that dominates $\Upsilon 5$. This situation may for example happen when the entry-condition for $\Upsilon 5$ is arises from a lexical assignment, rather than from structural reasoning. The same is actually the case with $\Upsilon 1$ in the example above!

Thus, the network we now obtain would not be fully connected, *without* the *Start* node. This is the point why there always has to be a *Start* node. With that in mind, the network we obtain is given in Figure 4.4.2.

$\mathit{Start}_{\{\theta_1,\theta_2\}}[\Upsilon 5]_{\{\theta_1\}}[\Upsilon 6]_{\{\theta_1\}}$ $[\Upsilon 1]_{\{\theta_1,\theta_2\}}[\Upsilon 2]_{\{\theta_1,\theta_2\}}[\Upsilon 3]_{\{\theta_1\}}[\Upsilon 4]_{\{\theta_2\}}$

Figure 4.4: A simple multilingual network of structural rules including *Start*

Summary

In this chapter I focused on the relation between linguistic meaning and surface form, in particular the realization of a linguistic meaning's dependency structure. To that end, I discussed how dependency relations can be related to morphological strategies that realize them. Because the relation is mediated by abstract morphological categories (like in Government & Binding's theory of case), the relation is not language-specific but cross-linguistic. In this way, DGL can provide a linking theory that overcomes the criticism that has it that the interpretation of a wordform as a particular "role" is stipulated. Subsequently, I focused on how we can provide a logical calculus in which a sentence's linguistic meaning is built in a compositional, monotonic way as a reflection of the analysis of its surface form. I used a resource-sensitive categorial proof theory for the analysis of form, alike the Lambek-style calculi used in categorial type logic. However, rather than operating on type-logical terms to reflect semantics using a Curry-Howard style correspondence, the proof theory in DGL operates on hybrid logical terms. Using categories that indicate head/dependent asymmetries, and a formalization of morphological strategies, I showed how we can obtain the kind of linguistic meaning representations discussed in earlier chapters through a compositional analysis of sentential form.

SUMMARY TO PART 1

> "It is one thing to use language;
> it is quite another to understand how it works."
> Anthony Burgess, *Joysprick*

OVERVIEW

In this first part I presented Dependency Grammar Logic (or DGL), both in its aspects as a *dependency grammar* and in its logical formalization as a *categorial grammar*. It is what could suitably be called a *categorial modal logic*: It combines substructural proof theory with hybrid logic. I would like to argue that DGL presents several innovations over the traditions it builds on.

To begin with, DGL uses *hybrid logic* to represent the linguistic meaning of a sentence. This presents several advantages over the traditional use of typed logics, after Montague. Hybrid logic enables us to create ontologically rich representations, which are needed -beyond any doubt- to adequately represent natural language meaning. Formally equivalent logical systems like first order logic or the λ-calculus are only able to do so at the cost of undecidability, whereas the hybrid logic DGL employs provably stays within the realm of the computable. Moreover, an interesting aspect of hybrid logic is its explicit reference mechanism, provided by the @-operator. With the @-operator, we can (theoretically) separate the *fact that* something refers from the actual interpretation of the reference. That interpretation can subsequently be performed in a DRT-like theory of discourse, again formalized using hybrid logic. The separation of reference from its interpretation is important: If a well-formed sentence has a linguistic meaning that cannot be interpreted in the context, then that should only imply that the sentence is *incoherent*, not that it is ill-formedned.

In Chapter 2 I explained hybrid logic and how to create a discourse theory using hybrid logic, styled after some of the intuitions behind DRT. The latter formalization, in and by itself, presents various interesting advantages. Because hybrid logic has a proof system, the discourse theory comes immediately equipped with an inference system. Furthermore, as we shall see later on, the *sorted* nature of hybrid logic makes it straightforward to formulate a discourse representation theory that takes information structure into account. Finally, formulating the discourse theory *and* the grammar's representation of a sentence's linguistic meaning in one and the same logical framework has its obvious practical advantages.

In Chapter 3 I presented an explanation of dependency relations in terms of morphological categories and morphological strategies, and the possibility of formalizing the latter in DGL. This is nothing new - it is a natural continuation of the Praguian tradition. However, it presents a significant counter-argument to criticisms voiced in lexical semantics, for example by Dowty, Davis and Wechsler. The criticism is that there is no clear way in which one can define the relation between roles and forms (in a grammar). The combination of language-specific morphological strategies and language-universal morphological categories, with the latter being closely related to dependency relations, can be understood to prove otherwise. What is more, the language-universal character of morphological categories lifts DGL from a language-specific account (like the rather counter-intuitive account by Wechsler for HPSG (1995)) to an account that predicts *cross-linguistic generalizations* about the realization of (linguistic) meaning. And with that, the dependency grammar-based perspective vindicates over phrase-structure grammar, as the latter's derivation-based description of surface form can hardly give rise to such generalizations.

The explanation of dependency relations in terms of their semantic import arguably gives a deeper account of the *meaning* of dependency relations than is present in most contemporary dependency grammar accounts. There, one often finds a description of what dependency relations can be *distinguished*, but not how they *contribute* to a sentence's linguistic meaning. With the first attempt at describing the semantic import of dependency relations presented here, this 'contribution' is shed more light on. For example, I showed how dependency relations may contribute to the causal and temporal structure of a sentence's linguistic meaning, thus helping to determine its (overall) aspectual category. I formalized, and extended, Moens &

Steedman's theory of aspectual categories and aspectual change to illustrate that impact.

Finally, as Chapter 4 explained, a detailed hybrid logical description of linguistic meaning can be tied to the resource-sensitive proof theory of categorial type logic. I showed how the categorial calculus can be used to analyze form and deliver the kind of rich representation of a sentence's linguistic meaning as discussed in the previous chapters. Within the categorial calculus, I discussed in detail how head/dependent-asymmetries can be captured, and how morphological strategies can be modeled. Furthermore, I showed how linguistic meaning can be formed compositionally, in parallel to the analysis of form. The two principal issues in that discussion were DGL's linking theory, relating predicate-valency structures and syntactic categories, and the interpretation of word groups as particular types of dependents, (thus providing more substance to the counter-argument raised against criticism voiced in lexical semantics). Finally, I presented a proposal for how to construct multilingual grammar fragments in DGL, introducing the concept of grammar architecture into a categorial framework.

Altogether, Part I thus provides a dependency-based grammar formalism that finds its linguistic motivation in the Prague School of Linguistics, and which can construct logical descriptions of linguistic meaning in a compositional and monotonic way using a categorial analysis of a sentence's form. Attention has been paid to both the formulation of (lexical and) linguistic meaning, and the description of surface form. Taken together, this provides us with a good basis for Part II - with some of the theses already partially (or even entirely) covered:

- **Ad Thesis 5**: The concept of grammar architecture has been introduced. (Chapter 4)

- **Ad Thesis 6**: The formal foundations for a compositional account of the formation of linguistic meaning has been formulated. (Chapter 4)

- **Ad Thesis 7**: A formalization of the semantic imports of many dependency relations has been given. (Chapter 3)

FINAL REMARKS

From a Praguian perspective, it is only the inclusion of information structure at the level of linguistic meaning that will make it a *complete* description of the linguistically realized meaning of a sentence.

The next part addresses information structure in terms of its formal realization and its representation at the level of linguistic meaning. Hybrid logic with its @-operator provides an ideal setting for providing an (intensional) logic of information structure, including binding within and across sentence boundaries. By the end of the second part, we shall thus have an insight in how linguistic meaning, with its information structure, can be established on the basis of a sentence's form, and how that linguistic meaning can subsequently be interpreted in the larger discourse context.

Finally, to round off the summary of the first part, let me make some remarks on what I did *not* discuss. For example, I left open the question of how to parse with grammars written in DGL. This question can be answered very briefly, here. To begin with, the (categorial parts of the) fragments discussed in the first part can be implemented in Moot's Grail, a theorem prover for categorial type logics described in (1998). (All of the fragments to be presented in Part II have in fact been implemented in Grail.) Alternatively, one could parse the fragments with an implementation of the chart parser I described for example in (1999b), where I presented an approach to parsing with categorial type logics based on earlier proposals by Hepple (1996a; 1998) and Moortgat (1996).

PART II

THE CATEGORY OF INFORMATIVITY

"...first let me say that I use the word information *to mean a state of knowledge, which may range from total ignorance of everything except the meanings of words up to omniscience; and by informational I mean relative to such a state of knowledge. Thus by 'informationally possible', I mean possible so far as we, or the person considered to know. Then the* informationally possible *is that which in a given information is not perfectly known not to be true. The informationally necessary is that which is perfectly known to be true ... The information considered may be our actual information. In that case, we may speak of what is possible, necessary or contingent,* for the present."

– Charles Sanders Peirce.

CHAPTER 5

THEORIES OF INFORMATION STRUCTURE

In this chapter I discuss various theories of information structure that stress the importance of explaining both the expression of information structure and how information structure bears upon linguistic meaning. Based on reflections on these theories, I motivate why I opt for the Praguian approach, and I discuss core concepts like contextual boundness and topic-focus articulation. At the end of the chapter, I explain how contextual boundness can be indicated in the hybrid logical formulation of a sentence's linguistic meaning, and how we can derive a topic-focus articulation from the individual nodes' indications of contextual boundness. I also point out how we are going to interpret a sentence's topic-focus articulation model-theoretically, and why dependency relations are necessary for explaining (the realization of) information structure.

> *[the phenomena at issue here] have to do primarily*
> *with how the message is sent and only secondarily*
> *with the message itself, just as the packaging of*
> *toothpaste can affect sales in partial independence*
> *of the quality of the toothpaste inside.*
>
> – Wallace L. Chafe

5.1 INFORMATION STRUCTURE IN LINGUISTIC MEANING

In general, the purpose of a (declarative) sentence is *to communicate meaning.* As most sentences are uttered in the context of a larger discourse, there is a side-condition on this communication: the sentence's meaning needs to be *coherent* with the preceding context. Arguably, the claim behind information structure as a theoretical construct is that it helps us to explain *how* the meaning a sentence conveys can be coherent with respect to a larger discourse.

From an abstract viewpoint, information structure tries to divide the meaning of a sentence into several parts. One such part, which I call for the moment the *Relatum*, states how the meaning of the sentence *purports* to relate to the already established discourse. It helps to set, as it were, the conditions under which the meaning of the sentence can be true, provided these conditions are met.[1]

Next to the Relatum we can distinguish a part that I call here the *Attributum.* The Attributum says something *about* the Relatum, by qualifying or modifying the meaning it is related to in the context. Thus, whereas the Relatum of a sentence's linguistic meaning could be understood as specifying certain 'given' information, it would be only partially correct to perceive of the Attributum as the 'new' information. The Attributum need not provide information that is entirely new, in an additive fashion. It may well indicate the need to change, modify, a piece of information that had previously been established in the discourse.

An important issue now is how a sentence's surface form realizes the information structure of the underlying linguistic meaning. After all, whereas the meaning that is being communicated is by nature *multi-dimensional* [2], wordforms can only be uttered in a *linear order.* Thus, we need to project the complex underlying structures onto a single dimension, and thereby we are constrained by language-specific rules defining grammaticality.

The basic idea is that forms are *iconic* of their informativity - they carry what I call here *structural indications of informativity.* It naturally depends on the type of language what means are available to indicate informativity. For example, Slavonic languages like Czech or Russian predominantly use word order, structuring a sentence such that the words realizing the Relatum appear at the beginning, followed by the Attributum - see (294) for some possibilities in Czech, and their English counterparts in (295).

(294) **Czech**

a. $\underbrace{\text{Včera Elijah četl}}_{\textit{Relatum}}\ \underbrace{\text{Katce knihu}}_{\textit{Attributum}}.$

b. $\underbrace{\text{Katce Elijah včera četl}}_{\textit{Relatum}}\ \ \underbrace{\text{knihu}}_{\textit{Attributum}}\ .$

---

[1] An important point here is that the Relatum *conditions* the meaning - for information structure to make any explanatory impact, we must distinguish information structure and the linguistic meaning it is part of from the subsequent interpretation of the sentence in the setting of the established discourse context. The purported relation, or contextual reference in a broad sense, is *not yet resolved.* It is the (im)possibility of resolving the reference that renders a sentence's linguistic meaning (in)coherent. Also, note that information structure is not equal to truth-conditions - (Sgall et al., 1986; Hajičová et al., 1998; Peregrin, 1995).

[2] In the sense that conceptual structures are not linear.

c. $\underbrace{\text{Knihu Elijah včera četl}}_{\textit{Relatum}}\ \underbrace{\text{Katce}}_{\textit{Attributum}}$.
"Elijah read a book to Kathy yesterday."

Thus, even though Slavonic languages have a relatively free word order, that word order is by no means arbitrary: It indicates informativity, and therefore the sentence's felicity may vary depending on the context.

On the other hand, a language like English already uses word order as a morphological strategy to realize Case, a rich inflectional system being absent. To realize informativity, English predominantly uses other means, in particular tune. The examples below (295) illustrate the use of tune to realize the same information structures as in (294). Pitch accent is indicated by $\textsc{small caps}$.

(295) **English**

a. $\underbrace{\text{Yesterday Elijah read}}_{\textit{Relatum}}\ \underbrace{\textsc{a book to Kathy}}_{\textit{Attributum}}$.
b. $\underbrace{\text{Elijah read}}_{\textit{Relatum}}\ \underbrace{\textsc{a book}}_{\textit{Attributum}}\ \underbrace{\text{to Kathy yesterday}}_{\textit{Relatum}}$.
c. $\underbrace{\text{Yesterday Elijah read the book}}_{\textit{Relatum}}\ \underbrace{\textsc{to Kathy}}_{\textit{Attributum}}$.

Besides tune, English can also use function words to realize informativity. For example, a definite determiner prototypically indicates that the meaning of the modified noun is contextually given (295c), whereas verbal auxiliaries can be used to make the main verb more marked (296).

(296) **English**

a. $\underbrace{\text{Yesterday Elijah read}}_{\textit{Relatum}}\ \underbrace{\textsc{a book to Kathy}}_{\textit{Attributum}}$.
b. $\underbrace{\text{Yesterday Elijah}}_{\textit{Relatum}}\ \underbrace{\textsc{did read}\text{ a book}}_{\textit{Attributum}}\ \underbrace{\text{to Kathy}}_{\textit{Relatum}}$.

Finally, we also encounter languages that have a rich nominal morphology and -hence- a relatively freer word order, which realize information structure primarily through affixation. An often-cited example is Japanese, where the *-wa* suffix marks a contextually given item and *-ga* is often associated with newness (though see (Heycock, 1993)). Haiman mentions other languages that have similar constructions (cf. (Croft, 1990),p.10). For example, the Papuan language Hua uses a suffix *-mo* to indicate a sentence's

Relatum. Furthermore, although Turkish normally uses word order to indicate information structure (Hoffman, 1995b; Hoffman, 1995a) Haiman notes that the -*sA* suffix can mark contrast ("contrastive topic"). Interestingly enough, Tagalog also uses morphological means to indicate informativity but, as Kroeger observes, it depends on the dependency relation that is involved whether the suffix indicates that the item belongs to the Relatum or to the Attributum (1993)(pp.64-69,pp.130-131). Applying what Kroeger calls the -*ay*-Inversion construction to an **Actor** makes the **Actor** part of the Relatum, but using -*ay*-Inversion with any other dependency relation indicates the dependent specifies something new. Finally, Engdahl & Vallduví mention in (1994) Navajo and Vute, languages in which Attributa are associated with a particular suffix.

To recapitulate, we see that there is an interesting variety in how languages can *realize* information structure, and that it is necessary to distinguish different types of dependency relations to give an adequate account. Depending on the type of language we are dealing with different types of structural indications of informativity are *predominantly* used, like word order in Czech, tune in English or a dedicated morphological suffix in Japanese. 'Predominantly' should be stressed here, because no language appears to be making *absolute* use of one and only one means.

For example, if we take the two typologically rather different languages that Sgall *et al* contrast in (1986), English and Czech, then we can see that English can use word order-related constructions like topicalization or focal fronting, and that Czech can use tune to mark contrast. If we take languages that we can conceive of as being 'somewhere inbetween' like Dutch or German, then we can observe an even more obvious continuum between the use of word order and tune as structural indications of informativity. Sgall *et al.* often present examples like (297), illustrating the use of word order in English.[3] Naturally, any theory of information structure should be able to handle these.

(297) a. Christopher was writing his dissertation on the weekends.
b. On the weekends, Christopher was writing his dissertation.

It is then this *relatively predominant* use rather than an absolute use of

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[3] Observe also the word order variation in (295)

different structural indications of informativity that has important several consequences for a theory of information structure, modeled in a particular grammar framework.[4]

First of all, because grammar describes the relation between *function* (linguistic meaning) and *form*, the framework underlying the grammar needs to be powerful enough to model the various strategies a language may adopt as structural indications of informativity, and the potential interaction between these strategies within a single language.

Secondly, a theory of information structure -as an inherent component of a theory of *language*- must be able to make predictions about how information structure can be realized *cross-linguistically.* Naturally, a language's inventory of strategies to structurally realize informativity depends on its typological characterization. But, because strategies are relative rather than absolute, each language shares at least part of its inventory with other languages. Consequently, lest the theory gives rise to a rather *ad hoc* explaination of information structure, it should be possible to lift the model of how a particular strategy contributes to realizing information structure in one language to a different language if the latter employs that same strategy. Thus, one would for example expect that a model of information structure for German would show significant overlap with similar models for Dutch and English. And that, where differences do arise, they would be explainable by language-specific constraints on grammaticality (or "prosodic wellformedness", (Morrill, 1994)).

Below I describe various theories of information structure, and reflect on them from these two perspectives of cross-linguistic explanation and (formal) coverage. The theories I describe are contemporary frameworks that one often encounters in formal grammar or formal semantics: the Praguian theory of topic-focus articulation (§5.2), Steedman's Theme/Rheme (§5.3), and Vallduví's information packaging (§5.4). Thus, my coverage is by no means 'total' but there is a good reason for discussing just these theories. Namely, these are the only theories that consider both the "semantics" of information structure and its modeling in a grammar framework - unlike the 'degrammatized' theories of Karttunen or Rooth, or most of the Government & Binding tradition which considers only the *syntax* of information

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[4] Certainly from the Praguian point of view, as well as the other theories discussed here, where the modeling of information structure is a matter of *grammar.*

structure and not its reflection in linguistic meaning.[5] For other overviews, see for example Kruijff-Korbayová (1998), Hajičová and Kruijff-Korbayová (1999), or Vallduví (1990).[6]

After these discussions, I provide in §5.5 a brief reflection from the viewpoint of the above remarks about theories of information structure, and I present in §5.6 an overview of how information structure is modeled in DGL.

5.2 INFORMATION STRUCTURE IN THE PRAGUE SCHOOL

Information structure has since long been an essential ingredient of the view on language developed in the Prague School of Linguistics. Nowadays, a distinction is made between the *topic* of a sentence, and the *focus*. These two terms can be traced back to Weil's work in the nineteenth century (1844). Weil's work was resumed by several German linguists in the decades around the turn of the last century. Subsequently, the Prague School of Linguistics started paying systematic attention to issues of information structure, starting with Mathesius's work (1936; 1975). Mathesius recognized that the distinction between topic and focus was important to problems ranging from tune to word order, and formulated an account on the basis of a structural comparison of Czech and English (cf. also (Sgall et al., 1986),p.175)).

Within the Functional Generative Description, the theory of topic-focus articulation (or TFA for short) has been elaborated by Sgall, Hajičová, and their collaborators for more than four decades now. Hajičová presents in (1993) a brief overview of the developments that include Sgall *et al* (1973; 1980; 1986) and various articles primarily by Sgall and Hajičová. A recent dialogue examining TFA and its relation to formal semantics can be found in Hajičová, Partee, and Sgall (1998).

There are three principal ingredients to the Praguian theory of TFA:

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[5] Theories like Grosz & Sidner's (1986), Grosz et al's (1995) and Hahn & Strube's extension of the latter (using Daneš's theory of thematic structures) are all concerned with discourse structure rather than grammar, and therefore fall outside the scope of this dissertation. See Kruijff-Korbayová (1998) for a discussion of how these theories relate to the Praguian theory that I do discuss here. For reasons of time I am not able to discuss Zubizaretta (1998) or Lambrecht (1996). Both accounts appear to deserve interest, particularly Zubizaretta's as she takes a perspective on information structure that is modeled on the basis of word order phenomena and tune in Germanic and Romance languages.

[6] Vallduví's description of Sgall *et al*'s theory of topic-focus articulation (1986) is, however, debatable.

i. the *topic* and *focus* dichotomy that divides a sentence's linguistic meaning into a contextually given topic (the Relatum) and a focus that is *about* the topic (the Attributum);

ii. *contextual boundness*, a characterization of an individual head's or dependent's informativity, being either *contextually bound* or contextually nonbound; and,

iii. *communicative dynamism*, which is a relative ordering over the heads and dependents making up a sentence's linguistic meaning indicating how informative they are relative to one another.

Furthermore, we have the closely related concepts of *salience* (discourse activation) and the *Stock of Shared Knowledge.* Both play an important role in the discourse interpretation of TFA (Sgall et al., 1986; Hajičová, 1993).

An important characteristic of FGD's TFA is that the terms topic and focus are *not* primary notions, like their counterparts in other theories. Rather, topic and focus are based on the structural notion of contextual boundness.[7] Each dependent and each head in a sentence's linguistic meaning is characterized as being either contextually bound or contextually nonbound. Intuitively, items that have been activated in the preceding discourse may function as contextually bound (CB), whereas non-activated items are always contextually nonbound (NB) (Sgall et al., 1986)(p.54ff,p187ff). Mostly, an item is activated by introducing it explicitly into the discourse. Important about contextual boundness is, though, that it is a *linguistic* opposition, reflected in the structuring of linguistic meaning and its realization - it is not precise to equate contextual boundness to the discourse (or cognitive) opposition of given/new. For example, a previously item (CB) may occur in a contrastive focus, and we can present items as CB if they are activated by the situation of the discourse or can be activated indirectly by for example association (Hajičová et al., 1998)(p.59). In other words, contextual boundness is an issue of linguistic presentation.

Given this characterization, and the internal structure of the sentence's linguistic meaning, we can derive the actual topic and focus. To that end, Sgall *et al* define in (1986) the following procedure (p.216).

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[7] To quote Sgall *et al.*: "If the notions of topic and focus (as parts of a tectogrammatical representation) are characterized on the basis of contextual boundness, then we don't have to worry about questions whether topic and focus are a single (deep or surface) constituent [...]." (1986)(p.188).

Definition 17 (FGD's Topic-Focus Articulation). *Given a tectogrammatical representation of a sentence's linguistic meaning,*

- *the main verb belongs to the focus if it is contextually nonbound, and to the topic if it is contextually bound;*
- *the contextually nonbound nodes depending on the main verb belong to the focus, and so do all nodes (transitively) subordinated to them;*
- *if some of the elements of the tectogrammatical representation belong to its focus according to either of the above points, then every contextually bound daughter of the main verb together with all nodes (transitively) subordinated to it belong to the topic;*
- *if no node of the tectogrammatical representation fulfills the first two points above, then the focus may be more deeply embedded; special rules for the determination of focus are applied in these cases.*

⊛

In FGD, the *scale of communicative dynamism* defines a (partial) order over the nodes in a sentence's linguistic meaning, after Firbas's original notion of communicative dynamism (see Firbas (1992) for a recent formulation). If we project the linguistic meaning's tree to a line, then we obtain a reflection of that order. The *topic proper* and the *focus proper* are the least respectively most communicatively dynamic elements in a sentence's linguistic meaning. In the projected (deep) order, the topic proper corresponds to the leftmost item, whereas the focus proper is identified by the the rightmost element.

Hajičová and Sgall note in (Hajičová et al., 1998)(p.56ff) that there is a strong correspondence between communicative dynamism and word order (and, indirectly, tune). This certainly holds for languages like Czech. Dependents that are contextually nonbound are considered to be communicatively more dynamic, and occur prototypically *after* the head, whereas contextually bound dependents are less dynamic and should occur before the modified head. The mutual ordering of contextually nonbound dependents thereby follows what is called the *systemic ordering*, the canonical ordering in which complement types occur in a given language (Sgall et al., 1986; Sgall et al., 1995). On the other hand, FGD considers the order of contextually bound complements to be only determined by their mutual communicative dynamism. The examples in (298) give a brief illustration of the above ideas. Also, recall the earlier examples (297) and (295).

(298) a. **Czech** Co Elijah udělal? (**English** What did Elijah do?)

Elijah koupil knihu.
Elijah-CB bought-NB book-NB.

"Elijah bought a BOOK."
Topic={**Actor**:Elijah}, Focus={buy, **Patient**:book}

b. **Czech** Co Elijah koupil? (**English** What did Elijah buy?)

∅ koupil knihu.
he-CB bought-CB book-NB

"He bought a BOOK."
Topic={**Actor**:he, buy}, Focus={**Patient**:book}

Definition 17 also covers cases where the focus is deeper embedded. Thus, the dependent(s) constituting the focus do not modify the main verbal head but (transitively) one of its dependents. In the example in (299), only the dependent realized as *s kapsami* (**English** "with pockets") belongs to the focus, the rest of the sentence's linguistic meaning constitutes the topic. Consider also (300).

(299) **Czech** Jaké nosí krtek kalhotky?
(**English** "What trousers does the mole wear?")

Krtek nosí kalhotky s kapsami.
mole-CB wears-CB trousers-CB with pockets-NB

"The mole wears trousers WITH POCKETS."
Topic={**Actor**: mole,wear,**Patient**: trousers}, Focus={**GenRel**:pockets}
(Kruijff-Korbayová, 1998)(p.27)

(300) **English**
(What teacher did you meet yesterday?)
[(Yesterday)$_{cb}$ (I)$_{cb}$ (met)$_{cb}$ (the teacher)$_{cb}$]$_{T}$ [(of CHEMISTRY)$_{nb}$.]$_{F}$
– cf. (Sgall et al., 1986), (Hajičová et al., 1998)(p.135)

Thus, the primary notions contextually bound and contextually nonbound are *recursive* in the sense that contextually nonbound items can be embedded under contextually bound items and *vice versa*.

In the general case, neither topic nor focus is a single item, as (299) or (301) show.

(301) **English**
(What happened to Jim?)
A burgler INJURED him.
Topic={**Patient**:he}, Focus={**Actor**: burglar, injure} (Hajičová, 1993)

Petkevič notes in (1987; in prep) that Definition 17 does not cover some special cases of topic-focus articulation that he calls "split semantemes". The topic-focus articulation of a sentence is represented at the level of linguistic meaning, and at that level we do not have separate nodes for function words or even more local aspects of form. A sentence's linguistic meaning only has nodes that represent what in FGD are called auto-semantic units or semantemes. However, from the viewpoint of a sentence's topic-focus articulation it is not only the whole semanteme as such that can be determined as either contextually bound or contextually nonbound. Petkevič illustrates the need for a more refined assigned by examples like (302).

(302) **English**
a. I SHALL do it, not that I HAVE already done it.
b. I saw not only a single mouse there but several MICE.

For example, Petkevič argues that in (302a) the specifications of the verbal Tense of both occurrences of *do* belong to the focus, whereas both occurrences of the head *do* belong to the topic. A similar picture arises from (302b), only then for the specification of number.

Over time, several proposals have been made how to formalize FGD's theory of TFA. In general, these proposals either focus on the (truth-theoretic) interpretation of a sentence's topic-focus articulation, or have as their main concern the grammar's representation of a topic-focus articulation.

Both represent rather long traditions. FGD received its first formalization in Sgall *et al*'s (1969), where the authors were concerned with providing a "mathematically -thus linguistically- interesting description of (linguistic) meaning."[8] Sgall (1980) presents the first formalization of FGD's TFA.

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[8] The kind of grammar that Sgall *et al* present in (1969) still employs phrase structure-based notions, contrary to the later work (Sgall et al., 1986).

Sgall first constructs an automaton (roughly a complex pushdown store automaton) that is able to generate representations of a sentence's linguistic meaning, including marking of contextual boundness. Subsequently, a transducer is given that completes the representation -as it were- by deriving the sentence's topic-focus articulation, based on the contextual boundness marking. Petkevič extends this type of description in (1987; 1995; in prep). Petkevič's formalization is couched in a larger reformulation of FGD's generative description of linguistic meaning, and includes solutions to several of the problems noted on the previous page.

After Sgall *et al* argued the importance of distinguishing a sentence's topic-focus articulation for the felicity of its linguistic meaning *in a given context*, various attempts have been made towards the clarification of this view in *logical* terms. One group of such contributions was carried out within the framework of an intensional logic, namely Tichý's transparent intensional logic. The basic issues involved in formulating TFA in transparent intensional logic were discussed by Materna and Sgall (1980) and by Materna, Sgall and Hajičová (1987). Vlk (1988) provided a procedure for translating the tectogrammatical representations generated by FGD into Materna *et al*'s logical representations of transparent intensional logic.

Other, more recent developments are based on Partee's *tripartite structures* or on a logical dynamic perspective as arising from *dynamic semantics*. (See (Muskens et al., 1996) for a general description of logical dynamics and its use in describing natural language interpretation.)

Peregrin (1995) is the first attempt to construct a more dynamic account of TFA. Following an approach that essentially goes back to Jackendoff (1972), Peregrin formalizes the intuition that the focus says something *about* the topic as a λ-term. The topic is modeled as an abstraction, to which the focus-term then can be applied.

To provide an account of the semantic effects of information structure, Peregrin provides an extensional theory of the truth of a sentence's topic-focus articulation. In this theory, $|| X ||$ stands for the extension of an expression 'X', whereby $|| X ||$ is a truth value if 'X' is a sentence, an individual if 'X' is a term, and a class of individuals if 'X' is a unary predicate. Then, a proposition whose extension is denoted by $| X |$ is associated with every expression X (understood as a presupposition associated with X) as given in (303).

$$(303)\quad \begin{array}{rcll} \mid X \mid & = & \mid\mid X \mid\mid & \text{if } X \text{ is a sentence} \\ & = & \mid\mid \exists y.y = X \mid\mid & \text{if } X \text{ is a term} \\ & = & \mid\mid \exists y.X(y) \mid\mid & \text{if } X \text{ is a unary predicate} \end{array}$$

The semantics of a formula $F\{T\}$, as the predication of F corresponding to the focus-part over a sentence's topic-part T, is defined in (304), cf. (Peregrin, 1995)(p.240). Note that $F(T)$ is (the β-normalization of) the standard application of F to T.

$$(304)\quad \begin{array}{rcll} \mid\mid F\{T\} \mid\mid & = & \text{true} & \text{iff} \mid T \mid = \text{true} \ \& \ \mid\mid F(T) \mid\mid = \text{true} \\ & = & \text{false} & \text{iff} \mid T \mid = \text{true} \ \& \ \mid\mid F(T) \mid\mid = \text{false} \\ & = & \text{false} & \text{iff} \mid T \mid = \text{false} \end{array}$$

The rather simple examples in (305) illustrate the basic idea.

(305) a. John WALKS: **Walk**{ **John** }

b. JOHN walks: $\lambda f.f($**John**$)$ { **Walk** }

Peregrin works out an extensional account of negation, basic quantification, and focus as exhaustive listing. On the basis of the definitions in (303) and (304) Peregrin defines a more dynamic account of $\{\cdot\}$. Dynamically, a predication $P(S)$ is true can be modeled as a statement saying that there exists an assignment of a value to a variable x such that $P(x)$ & $x = S$ is true. A similar construction can be defined for Peregrin's new mode of predication, $\{\cdot\}$. Given a concatenator }&, T }& F has a truth value if and only if T has a truth value, and it is true if and only T & F is true (in the sense of $P\&S$ as above).

As Peregrin observes himself, the definition he gives for the truth of a statement T }& F cannot be applied recursively. Kruijff-Korbayová extends Peregrin's proposal to an *intensional* approach in (1998), and provides definitions that can be applied recursively (see her p.78ff). Kruijff-Korbayová weaves an intensional (typed) theory of TFA into a discourse representation theory to create TF-DRT. In Chapter 9 I discuss Kruijff-Korbayová's TF-DRT in more detail, and I show how particular technical problems with TF-DRT can be solved by using hybrid logic.

Besides a dynamic account, Peregrin also briefly discusses the possibility to model TFA in terms of tripartite structures. The idea of using tripartite structures was first put forward by Partee in (1991), and is substantiated to a larger degree in Hajičová *et al*'s (1998). In the latter work, the authors discuss in Chapter 2 how a tripartite structure constisting of an *Operator*, a *Restrictor*, and a *Nuclear Scope* could model a sentence's information structure when it involves a focus-sensitive operator.[9]

Many subtleties have been glossed over in the above discussion of TFA. For more thorough exposes see Sgall *et al*'s discussion in Chapter 3 of (1986), and Hajičová *et al*'s discussion in (1998). Throughout the next chapters I devote more attention to the relation between information structure in the above Praguian sense, in particular to contextual boundness and its realization using word order and tune. Where appropriate the relevant Praguian references are given there. Finally, in Chapter 9 I discuss a model-theoretic account of the discourse interpretation of information structure, based on a reworked version of TF-DRT.

5.3 Steedman's Theme/Rheme

Steedman (1996; 2000c; 2000a) develops a theory of grammar in which syntax, information structure, and intonational prosody are integrated into one system. Steedman's main aim is to provide an information structure-sensitive compositional analysis of English phrased as a Combinatory Categorial Grammar. Therefore, this system is *monostratal*: the only proper representation of a sentence is the representation of its linguistic meaning: "... a theory of grammar in which phrasal intonation and information structure are reunited with formal syntax and semantics is not only possible, but much simpler than one in which they are separated."(Steedman, 2000a)(p.653)

Steedman recognizes two independent dimensions of information structure, both of which are relevant to its realization (Steedman, 2000a)(p.655). The first dimension defines a partitioning into a *Theme* and *Rheme*. This distinction is similar to the one proposed by Mathesius, the Praguian topic-focus articulation, and the Relatum/Attributum characterization I gave earlier - thus, Steedman's Theme/Rheme indicate how, informally put, the utterance relates to the preceding discourse context.[10]

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[9] Because I do not discuss focalizers in this dissertation, I omit further discussion. See for example (Hajičová et al., 1998)(p.39) for a fully worked out example of this approach.

[10] It should be observed though that his notion of Theme is *not* similar to Halliday's use of that term - inspite of Steedman's criticism of Halliday. For Halliday Theme relates to *thematic structure*, not to the information structure of an individual sentence.

Steedman also defines a second dimension of information structure. This dimension first of all partitions the Rheme into a *focus* and a *background.* The focus of a Rheme is that 'information' that is marked in the surface form, whereas the background of the Rheme is its unmarked part. In English, this corresponds to the focus being marked by a pitch accent, whereas the background is unmarked by either a pitch or a boundary. In a similar move Steedman divides the Theme into a focus and a background, with that difference to the Rheme that the Theme's focus is *optional.* There can, but need not, be a marked element in the Theme's surface realization.

This partitioning is related to Halliday's *Given-New* dichotomy (1985), and to the Praguian division of contextual boundness into contextually bound/contextually nonbound. It concerns the distinction between elements in the sentence's meaning which contribute to distinguishing the Theme and the Rheme from other *alternatives* that the context makes available, in the sense of Rooth's alternative sets (Steedman, 2000a)(p.656).

The examples below illustrate Steedman's characterization of information structure in more detail. Steedman formalizes the Theme of a sentence as a λ-term involving a functional abstraction, like Jackendoff or Peregrin. The Rheme is a term that can be applied to that abstraction, after which we obtain a proposition. As CCG is a categorial grammar combining a λ-calculus to represent linguistic meaning, this proposition has the same predicate-argument structure as the composition of the canonical sentence would have resulted in. For example, consider the example in (306a) and the representation of its Theme in (306b).

(306) **English**

a. (What did Kathy prove?)
(Kathy proved)$_{theme}$($\mathsf{P{=}NP}$)$_{rheme}$.

b. $\lambda x.prove'xKathy'$

Because the functional abstraction is closely related to the existential operator ∃, the context of (306a) could instantiate the existential as in (307).

$$(307)\quad \left\{ \begin{array}{c} \mathit{prove'\ undecidability'\ Kathy',} \\ \mathit{prove'\ canonicity'\ Kathy',} \\ \mathit{prove'\ infatomability'\ Kathy'} \\ \mathit{prove'\ P{=}NP'\ Kathy'} \end{array} \right\}$$

The set in (307) is an alternative set, i.e. a set of potential alternative instantiations. Steedman calls it the *rheme alternative set*, and it holds that the Theme *presupposes* the rheme alternative set whereas the Rheme *restricts* it.[11] The distinction of a focus and a background in the Rheme, and possibly in the Theme, helps to set it apart from other alternatives available in the context. In particular, we have that the focus within the Rheme restricts the Rheme alternative set presupposed by the Theme.

Furthermore, we can consider the situation in which a Theme indeed does have a focus, realized by a marked form. Steedman gives in (2000a)(p.659) the following example, (308).

(308) **English**
(I know that Marcel likes the man who wrotes the muscial.
But who does he ADMIRE?)

$$(\underbrace{\underbrace{\text{Marcel}}_{background}\ \underbrace{\textsc{admires}}_{focus}}_{Theme})(\underbrace{\underbrace{\text{the woman who}}_{background}\ \underbrace{\textsc{directed}}_{focus}\ \underbrace{\text{the musical}}_{background}}_{Rheme})$$

Steedman argues that the significance of having a pitch accent on “admire” seems to be in the context offering alternatives that only differ in the relation between Marcel and x. A marked Theme is represented as in (309).

(309) $\exists x. * admires' \ x \ marcel'$

The utterance of (308) would be infelicitous if the context would *not* contain an alternative, like the $\exists x.likes' \ xmarcel'$ we have here. The set of alternative Themes provided by the context of (308) is given in (310).

(310) $$\left\{ \begin{array}{c} \exists x.admires' \ xmarcel', \\ \exists x.likes' \ xmarcel' \end{array} \right\}$$

The kind of alternative set given in (310) is what Steedman calls the *Theme alternative set*. The Theme presupposes also this set, and it is the Theme's focus that restricts it.

Although Steedman does not discuss recursivity of focus and background, they appear to be recursive in the same sense as FGD's contextually bound/contextually nonbound distinction. For example, consider (311)

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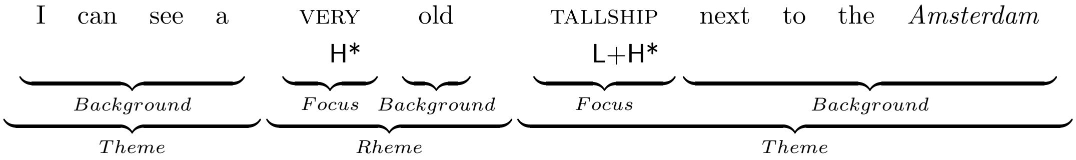
[11] As Steedman notes himself, for examples in (2000a)(p.10), alternative sets are used for reasons of exposition rather than presenting the only possible means of formalization. For example, it is not difficult to see how alternative sets in a sense ‘extensionalize’ accessibility in a modal logic's frame.

(311) **English**

(“Do you see that old boat next to the *Amsterdam*?”)
I can see a VERY old SHIP next to the *Amsterdam*.

One possible Steedman-style analysis of (311) is given in (312). Like in (299) or (300), the Rheme is modifies a head that is itself part of the Theme.

(312)



In (1996; 2000c) and in (2000a) Steedman elaborates a grammar that shows how the above kinds of information structure-enriched representations of a sentence’s linguistic meaning are related to English tune. Hoffman worked out in (1995b; 1995a) a version of CCG that models Turkish free word order. Hoffman coupled that to a slightly different theory of information structure that stands inbetween Steedman’s account and Vallduví’s information packaging. In Chapter 6 I devote more attention to Hoffman’s proposal for modeling free word order in a categorial grammar, whereas in Chapter 8 I return to Steedman’s account of English, focusing in particular on his model of tune.

5.4 INFORMATION PACKAGING

Starting with Vallduví (1990), various people have contributed to a perspective on information structure called *information packaging*, both in its aspects of discourse interpretation and grammatical realization. The basic idea of information packaging can be traced back to Chafe’s (1976), where he introduced the term explicitly as follows (p.28):

> “I have been using the term *packaging* to refer to the kind of phenomena at issue here, with the idea that they have to do primarily with how the message is sent and only secondarily with the message itself, just as the packaging of toothpaste can affect sales in partial independence of the quality of the toothpaste inside.”

Vallduví defines information packaging in (1990) as “a small set of instructions with which the hearer is instructed by the speaker to retrieve the information carried by the sentence and enter it into her/his knowledge store." (p.66) To work out the perspective emanating from this definition, Vallduví employs the file metaphor from Heim's File-Change Semantics (1982), constructing a theory of how information structure is interpreted in the larger context of a discourse. Vallduví's use of the file metaphor in (1990; 1994) has been criticized by Dekker and Hendriks in their (1994) and in (Hendriks and Dekker, 1995); see also Kuboň's (1998). It is for this reason that I devote relatively little attention to how Vallduví's information packaging guides discourse interpretation. Instead, I focus on Vallduví's basic proposal for characterizing information structure as a tripartite division of a sentence's surface form. Cross-linguistic justification for this characterization has been argued for by Vallduví in (1990) and together with Engdahl in (1994; 1996). (Engdahl and Vallduví, 1994; Manandhar, 1994) discuss integration of information packaging into HPSG, and Hendriks presents a proposal for including information packaging into a Lambek-style categorial grammar, (1994; 1996; 1997).

Vallduví reflects in Chapter 3 of his (1990) on various approaches to what he calls 'informational articulation'. Vallduví divides these approaches into *topic/comment* approaches and *focus/ground* approaches. Both (types of) approaches split a sentence, or rather its meaning, in two parts. The topic/comment approach splits the meaning into a part that the sentence is about, which is usually realized sentence-initially, and a comment. To follow Halliday, this 'topic' is the point of departure for what the sentence conveys.[12]

According to what Vallduví terms the focus/ground approaches, the sentence is divided into 'focus' and a 'ground', with the 'focus' being the informative part of the sentence's meaning. The ground anchors the sentence's meaning to what the speaker believes the hearer already knows. The 'focus' expresses what the speaker believes to contributes to the hearer's knowledge. The 'ground' is also known as 'presupposition' or 'open proposition' - the latter being explainable, at least formally, by Jackendoff's λ-term representation mentioned earlier.

Vallduví argues that both traditions suffer from various problems. Aside from terminological confusion, both traditions suffer from the fundamental

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[12] Note that Halliday (1985) calls this 'topic' the Theme, (Halliday, 1985)(p.59).

problem (according to Vallduví) that they are incomplete in their empirical coverage, *necessarily so* because "a binomial informational division of the sentence is simply not enough." (1990)(p.54) For example, consider the example in (313) adapted from Dahl (1974).

(313) a. What about John? What does he do?

$\overbrace{\underbrace{\text{John}}_{\textit{ground}}}^{\textit{topic}}\ \overbrace{\underbrace{\text{drinks beer}}_{\textit{focus}}}^{\textit{comment}}$

b. What about John? What does he drink?

$\overbrace{\text{John}}^{\textit{topic}}\ \overbrace{\text{drinks beer}}^{\textit{comment}}$

$\underbrace{\text{John drinks}}_{\textit{ground}}\ \underbrace{\text{beer}}_{\textit{focus}}$

The fact that the two perspectives partition (313b) *differently* is taken to show that "neither of them is by itself capable of capturing all the informational distinctions present in the sentence" (Hendriks, 1994)(p.93). Vallduví notices that there is a certain overlap in how the two perspectives divide (313b), and proposes to conflate the two perspectives into a single, hierarchically structured trichotomy.

Vallduví's trichotomy of a sentence's surface form is centered around a binary division according informativity, in the sense of the 'focus/ground' tradition. There is a *ground*, that anchors the sentence's meaning into the preceding discourse, and a *focus* that specifies the 'new' information. In addition, the ground is further divided into a *link* and a *tail*. According to Vallduví, the link specifies *where* to anchor the information specified by the focus, and the tail indicates *how* it fits there (1994)(p.5). Unlike is the case with FGD's contextually bound/contextually nonbound-distinction or Steedman's focus/background, Vallduví's primary notions are not (entirely) recursive. For example, we do have an information packaging analysis (314) for (300), with L indicating the link and F the focus.

(314) [Yesterday I met the teacher]$_L$ [of CHEMISTRY.]$_F$

However, because information packaging partitions a sentence's surface form (rather than its linguistic meaning), we have to consider *British* in (315) as having the same informative status as its head – see (Vallduví and Zacharski, 1994) for the argument.

(315) **English**
(Your system does not include an AMPLIFIER.)
The BRITISH amplifier comes HIGHLY RECOMMENDED.
(Prevost, 1995)(ex.5)

(316) [The BRITISH amplifier $]_L$ [comes HIGHLY RECOMMENDED. $]_F$

Vallduví cited examples from various languages in (1990), and presented together with Engdahl in (1996) an indepth study of how a large number of languages may employ different strategies to realize information packaging.[13] Consider the following examples for Catalan and English (317)-(319), cf. (Vallduví and Engdahl, 1996)(p.42), which illustrate the four abstract realizations of information structure that Vallduví distinguishes.

(317) *Link-focus sentences*: typical topic-comment structures, predicate-focus structures, categorical judgments.
a. The president $[_F$ hates CHOCOLATE].
El president$_1$ $[_F$ odia la XOCOLATA t_1].
b. The president $[_F$ CALLED].
El president$_1$ $[_F$ ha TRUCAT t_1].
c. The president$_1$ $[_F$ (I) wouldn't BOTHER t_1].
El president$_1$ $[_F$ no l'EMPRENYARIA t_1 *pro*].

(318) *All-focus sentences*: (a) neutral descriptions, news sentences, sentence-focus structures, thetic judgments; (b) *there*-sentences; (c) predicate-focus sentences where the locus of update is inherited.
a. $[_F$ The PRESIDENT called].
$[_F$ Ha trucat el PRESIDENT].
b. $[_F$ There are protests in the STREETS.]
$[_F$ Hi ha protestes als CARRERS.]
c. $[_F$ (He) HATES (it).]
$[_F$ L$_2$ 'ODIA e$_2$ *pro*.]

(319) *Link-focus-tail sentences* and *focus-tail* sentences: narrow focus, constituent focus, typical open-proposition structures.
a. The president $[_F$ HATES] chocolate.
El president$_1$ $[_F$ l$_2$'ODIA t$_2$ t$_1$,] la xocolata$_2$

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[13] Vallduví and Engdahl illustrate information packaging on English, German, Dutch, Swedish, Catalan, Hungarian, Turkish, and -for completeness' sake- Japanese.

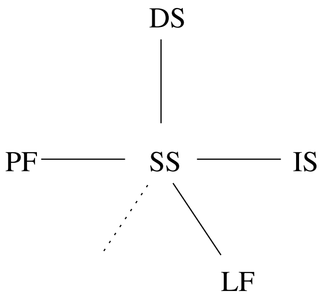

Figure 5.1: Vallduvi's grammar architecture incorporating information structure

b. The president hates [$_F$ CHOCOLATE.]
El president [$_F$ t$_v$ la XOCOLATA t$_1$,] odia$_v$.

Originally, Vallduví (1990) proposed to integrate information packaging into a GB-style architecture, with information structure as a *autonomous* stratum, next to deep structure (DS), logical form (LF), phonological form (PF), and surface structure (SS).

In (1994), Engdahl and Vallduví elaborate a different approach, making use of HPSG. The basic idea is to expand the CONTEXT field with a feature INFO-STRUCT, as shown in (320).

(320)
$$\begin{bmatrix}\text{CONTEXT} & \begin{bmatrix}\text{INFO-STRUCT} & \begin{bmatrix}\text{FOCUS} & \ldots \\ \text{GROUND} & \begin{bmatrix}\text{LINK} & \ldots \\ \text{TAIL} & \ldots\end{bmatrix}\end{bmatrix}\end{bmatrix}\end{bmatrix}$$

In addition, the PHON field is expanded to specify *accent* as well. Following Jackendoff, Engdahl and Vallduví represent the possible choices of accent as A,B, or unmarked (u).

(321) a. $Word \rightarrow \boxed{1}\begin{bmatrix}\text{PHON—ACCENT} & A \\ \text{INFO-STRUCT—FOCUS} & \boxed{1}\end{bmatrix}$

b. $Word \rightarrow \boxed{1}\begin{bmatrix}\text{PHON—ACCENT} & B \\ \text{INFO-STRUCT—LINK} & \boxed{1}\end{bmatrix}$

c. $Word \rightarrow \begin{bmatrix}\text{PHON—ACCENT} & u \\ \text{INFO-STRUCT—FOCUS} & [] \end{bmatrix}$

Naturaly, the accent-assignments in (321) are for English. The assignment of an accent to a particular *structure* (not necessarily a word, or a constituent in the phrase-structure grammar sense) imposes a constraint on how that structure is (to be) interpreted informatively. These specifications get instantiated, and inherited, by means of a rule schema that operates next to Pollard and Sag's *Head-Complement Schema* and *Head-Subject Schema*, cf. (Pollard and Sag, 1993)(p.402).[14]. In addition to satisfying these schemas, phrasal signs have to satisfy the INFO-STRUCT instantiations given by the rule in (322), cf. (Engdahl and Vallduví, 1994)(p.58).

(322) INFO-STRUCT *instantiation principles for English*:
Either (i) if a DAUGHTER's INFO-STRUCT is instantiated, then the mother inherits this instantiation (*for narrow foci, links and tails*), *or* (ii) if the most oblique DAUGHTER's FOCUS is instantiated, then the FOCUS of the mother is the sign itself (*wide focus*).

Using this rule, Engdahl and Vallduví illustrate how various information structure patterns can be analyzed, like object NP focus, VP focus, and verb focus. An advantageous aspect of their proposal is that the information structure can cut across standard phrases: subject/verb focus can also be analyzed, i.e. the notion of constituency *with respect to information packaging* is flexible.

Vallduví's theory of information packaging has found its way primarily into HPSG, due to (Engdahl and Vallduví, 1994) – for example, see (Kolliakou, 1998; Alexopoulou, 1999). Hendriks proposes in (1994; 1996; 1997) a categorial grammar system, based on Moortgat and Morrill's D calculus (1991), in which he tries to capture various insights of information packaging.

5.5 REFLECTIONS

At various occassions people have compared FGD's theory of TFA, Vallduví's information packaging, and Steedman's Theme/Rheme-based information structure. Vallduví presents in (1990) a discussion of various approaches, among which Praguian proposals, and a more recent discussion can

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[14] From the viewpoint of dependency grammar, it is interesting to observe that these two HPSG schemata are ID schemata - they concern immediate dominance, not linearization.

be found in (Vallduví and Engdahl, 1996). Hajičová and Kruijff-Korbayová compare in (1999) FGD's topic-focus articulation to all of the approaches discussed in this chapter, and conclude that the Praguian viewpoint presents various advantages over the approaches reflected on there. Finally, Kruijff-Korbayová and Webber focus in a number of papers on Czech and English and rely on a symbiosis of FGD's topic-focus articulation and on Steedman's theory, cf. (2000).

What all the approaches I discussed here have in common is that they conceive of grammar as the appropriate place to describe information structure and its realization. There are several interesting consequences that follow from that perspective.

First of all, the interpretation of information structure belongs to the level of *discourse*. Hence, the 'proposition' expressed by a sentence's linguistic meaning, including information structure, *cannot be assigned a truth-value* in the system of grammar for it *does not properly need to express one.*[15] This obviously goes against the views advanced by Montague Grammar and categorial grammar approaches that are based on it, like Morrill's (1994). But it is for this reason that Hajičová *et al* speak of a "Post-MG" semantics in (1998), following insights that were already present in earlier work like (Sgall et al., 1986).

We can carry the consequences of this viewpoint further. For one, the crisp division of the language system into -roughly- syntax, semantics and pragmatics can no longer be maintained, since information structure dissolves the clear borderline between what Morris and Carnap considered to be "semantics" and "pragmatics". This is what Peregrin calls in (1999) *the pragmatization of semantics.* The meaning expressed by a sentence as such is no longer context-independent, as Carnap assumed. The sentence's linguistic meaning with is information structure signifies a dependence on the larger context in which the sentence is uttered.

At the same time, information structure is a property that belongs to the level of individual sentences – it has no reference to the orthogonal dimension of *thematic structure* that deals with *textual organization.* It is to this larger organization that Halliday's Theme contributes, independently of the

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[15] I deliberately put proposition inbetween quotes here, as I do not mean any more technical notion by it than "a statement that has a truth-value". Different theories may formalize the meaning of a sentence differently at the level of grammar; I am not concerned with those differences here.

local sentential organization. There is a close relation between information structure and thematic structure, as argued for by for example Halliday and by Daneš, but their strategies have different aims.[16]

Steedman's use of the term Theme must therefore be distinguished from Halliday's, as Steedman does acknowledge in (2000a). Steedman's definition of Theme diverges from Halliday's Theme for example in that Steedman's Theme (i) does not have to be sentence-initial, but can be ordered either before or after the Rheme; (ii) the Theme can contain multiple experiental elements (for example, multiple circumstantial modifiers, but also multiple participants, as well as the main verb), and (iii) disjoint parts of a sentence might belong to the Theme, cf. (2000a)(p.7).

However, whereas Steedman thus places his Theme squarely within the realm of information structure, Vallduví argues that the description of a sentence's role in thematic structure and its information structure should be *conflated* into a single construct, namely his focus/ground. According to Vallduví, the link-part of the ground corresponds to Halliday's Theme (cf. (1990; 1994), see also (Hendriks, 1994)) and arguably "provides the explanation for sentence-initial topiclike phrases." (1990)(p.54) However, to begin with it is not clear how Vallduví provides a model of what, in Halliday's terms, would be the first *experiental* element, which need not be the first phrase (323a), if it is a phrase at all (323b-c).

(323) **English**

a. Now, ... (Bateman, p.c.)

b. [$_{Theme}$ From house to house] I wend my way.
(Halliday, 1985)(p.40)

c. [$_{Theme}$ On the ground or in the air] small creatures live and breathe.
(Halliday, 1985)(p.40)

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[16] Consider the following description of the relation between Theme/Rheme, and Halliday's information structure, from (Halliday, 1985)(pp.299-300): "There is a close semantic relationship between information structure and thematic structure (...). Other things being equal, a speaker will choose the Theme from within what is Given and locate the focus, the climax of the New, somewhere within the Rheme. But although they are related, Given + New and Theme + Rheme are not the same thing. The Theme is what I, the speaker, choose to take as my point of departure. The Given is what you, the listener, already know about or have accessible to you. Theme + Rheme is speaker-oriented, while Given + New is listener-oriented."

But, worse, Vallduví's argument for the need for such a conflation is far from convincing. There are alternative ways of explaining topic-initial phrases, without having any direct recourse to Halliday's Theme, and by obliterating the distinction between the two *orthogonal* dimensions of thematic structure and information structure Vallduví's focus/ground *in fact* no longer enables us to explain phenomena that are possible exactly because of the above mentioned orthogonality.

For example, Halliday gives in (1985) various examples of sentences in which the Theme is actually located in the New information. In (324a), "seen" is used contrastively, so it cannot be Vallduví's link, whereas (324b) purportedly can be analyzed as an all-focus sentence. Finally, example (324c) comes from Steedman, and has one reading in which Halliday's Theme corresponds to Steedman's Rheme focus

(324) **English**

a. [$_{New}$ [$_{Theme}$ I] haven't SEEN] you for ages.
(Halliday, 1985)(p.301)

b. [$_{New}$ [$_{Theme}$ The boy] stood on the burning DECK.]
(Halliday, 1985)(p.297)

c. [$_{Theme}$ NIXON] died.
cf. (Steedman, 2000c)(p.119)

Vallduví does address 'focus-preposing' (or focal fronting) constructions, which could be taken to indicate the problems noted above. Based on Catalan data, Vallduví argues that an analysis can be given whereby the focus *does* remain clause-final (Vallduví, 1990)(p.132) because an empty category is retained. Thus, Vallduví would have it, no problems arise with focal fronting since the general informational articulation of the sentence (325) can be maintained.

(325) [$_{IP}$ link [$_{IP}$ [$_{IP}$ **focus**] tail]]
(Vallduví, 1990)(p.132)

However, it can be seriously doubted whether Vallduví's analysis still stands any ground given the rejection nowadays of empty categories, a rejection prevalent in HPSG as well. Moreover, Vallduví's argument still leaves the issue outstanding that distinguishing a sentence's information structure from its role in the larger thematic structure does *not* indicate a redundancy, but is an essential difference between two opposite perspectives. Vallduví's strategy of imploding these two perspectives into a single characterization gives rise to more questions than it answers.

And, as even Vallduví points out himself, there are alternative ways of explaining the relation between thematic structure and information structure. Vallduví indicates that the Praguian scale of communicative dynamism could possibly overcome the noted 'failure' to explain sentence-initial topics (1990)(p.55).[17]. Hajičová and Kruijff-Korbayová voice the same opinion in (1999)(p.229).

Another consequence of placing information structure in grammar is that its description thus gets placed in the larger context of explaining the (grammatical) system of natural language. One issue that thus comes into view is that of cross-linguistic realization of information structure. In the approaches I discussed above we can find for example Mathesius's early work on English and Czech (1936), Sgall *et al*'s contrastive studies in (1986) and (Hajičová et al., 1998), and Vallduví and Engdahl's (1996) and Hendriks' (1994).

However, at least from a functionalist perspective, one would like to see this cross-linguistic study taken further: Namely, to the point where a *grammar* would describe information structure *cross-linguistically* in the sense of how languages differ in realizing information structure and what they have in common in their strategies. The cross-linguistic studies *observe*, but hardly *predict* - and prediction is what any proper theory should do, including one describing information structure and its realization.

In a certain sense Hendriks thus misses the point when he states that grammar frameworks need to be powerful enough to describe the different strategies languages employ in realizing information structure (1994; 1997). A grammar framework, incorporating a cross-linguistically adequate description of information structure, must be powerful enough to explain why languages differ in their strategies, and predict what they may have in

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[17] Interestingly enough, Vallduví says that "it must be pointed out that it [discerning communicative dynamism within information structure, GJMK] violates any autonomy-of-levels hypothesis, since it brings along a direct interaction at th esame level between thematic and informational considerations." (1990)(p.55) Although I do believe that Vallduví has a point here, the comment is slightly surprising in the light of the discussion above.

common. Obviously, this in a step further from simply realizing that there are different strategies and that we should be able to model them.

All of the approaches I discussed above distinguish themselves from other approaches by actually explicitly discussing the core function grammar performs in explaining information structure. They do so in different ways, though.

In the above we already argued that information packaging shows shortcomings on various points. First, its arguments for collapsing of thematic structure and information structure are disputable. Second, its characterization of the primary notions of ground and focus as partitions of a sentence's *surface form* leads to problems with recursivity, and appears at odds with the generally accepted idea of information structure being an aspect of linguistic meaning. Third, Engdahl and Vallduví do present in (1994) a proposal for how to integrate information packaging into HPSG and relate it to a model of tune, but the model remains -as the authors admit- simple. Neither do Engdahl and Vallduví, or Manandhar for that matter, show how one could explain word order as a strategy for realizing word order. (Kolliakou, 1998) and (Alexopoulou, 1999) do elaborate the HPSG-based approach in that direction. However, they do so using purely syntactic devices. Finally, going back to the Government & Binding model proposed in (Vallduví, 1990), or using Selkirk's prosody model (cf. (Steedman, 2000a)), would not overcome any of these problems. In any of these models, predicate-argument structure and information structure are separated. Steedman convincingly argues that this separation is wrong. Also in FGD's stratificational model, cf. Sgall et al's (1986) and Petkevič's (1995), where information structure is an ingerent component of linguistic meaning, we do not find a separation of levels that are responsible for realizing information structure, apart from others that would care for realizing "bare" linguistic meaning. From the perspective of FGD, including the larger (Praguian) viewpoint that surface syntactic phenomena like word order interact with tune to realize information structure, such a separation would go against the fundamental relation between linguistic meaning and its topic-focus articulation.

This then leads us to consider Steedman's approach, and FGD. Regarding their views on information structure, both place it at the level of linguistic meaning. They both employ primitive notions that are recursive (CB/NB, focus/background). Also, they allow for a moderate form of recursivity where it concerns Theme/Rheme or topic/focus: information structures can be embedded when it concerns embedded clauses (Hajičová et al., 1998)(p.160), (Steedman, 2000c)(§5.7.2).[18] Finally, it seems plausible to consider the contrastive topic marker *c* (Hajičová et al., 1998) as the counterpart of Steedman's Theme-focus, and the focus proper as the counterpart of Steedman's Rheme-focus.

Hence, at the level of information structure there appear to be various correspondences between Steedman's approach and FGD. However, they differ substantially where it concerns the underlying views on grammar. Steedman develops a monostratal formalism (CCG) in which surface form and underlying meaning (with information structure) are compositionally related, (Steedman, 2000a; Steedman, 2000c).

FGD, on the other hand, proposes a stratificational approach (Sgall et al., 1986; Petkevič, 1995; Petkevič, in prep). (Sgall, 1980) specifies transducers that generate a surface form given a topic-focus articulation, and (Petkevič, in prep) develops the mathematical devices to generate representations of sentential linguistic meaning with topic-focus articulation. FGD lacks further specifications of transducers to turn Petkevič's representations into surface forms, which is an acknowledged shortcoming (Sgall,p.c.). Furthermore, there appears to be a problematic difference between the linguistic view on the grammatical phenomena involved in realizing information structure, and their possible technical implementation in a stratificational framework. For example, we already noted earlier that information structure is often realized using a combination of various means like tune, morphology and word order. On a stratificational approach, one is -normally- technically forced to assume that there is a relation between these different means where word order restricts morphology, and morphology restricts tune. However, this seems implausible. There rather appears to be an *interaction* in which different linguistic means mutually restrict one another to construct a well-formed surface realization of the underlying information structure. We understand (Sgall et al., 1986) to argue for this interaction *linguistically*, but without further implementation of the framework it is difficult to judge whether this view could be maintained *technically*.

Steedman's CCG provides a grammar formalism in which information structure is compositionally related to an analysis of a surface form. (Steed-

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[18] For an earlier discussion of recursivity of TFA in FGD, see (Sgall et al., 1986)(§3.11).

man, 2000a) focuses on tune as a structural indication of informativity, though it would be incorrect to claim that Steedman's theory of information structure is reduced to prosody as done in (Hendriks, 1997). The variation in focus/background that Steedman explains using markedness *can* be related its realization as pitch accents, but need not be. The focus/background distinction can be applied to explain variations in word order realization as well, as Kruijff-Korbayová and Webber do. Kruijff-Korbayová and Webber's approach is purely semantic though, without any reference to grammar.

CCG has been extended to cover free word order. Hoffman (1995a) presents multiset combinatory categorial grammar (MCCG), which relates an account of Turkish word order to an information packaging-inspired theory of information structure. MCCG is a grammar framework that has a greater generative strength than CCG. Baldridge(1998; 1999) presents Set-CCG, a more conservative extension of CCG that is capable of explaining free word order (including Turkish) but which has the same formal and computational properties as CCG. What CCG, multiset combinatory categorial grammar, and Set-CCG all have in common is Steedman's *Principle of Adjacency*, (Steedman, 2000c). According to this principle combinatory rules may only apply to finitely many phonologically realized and *string-adjacent entities.* The emphasized phrase is important. As is obvious from MCCG and Set-CCG, the Principle of Adjacency means that one models variability of word order *directly in the lexicon.* The MCCG or Set-CCG lexical categories impose less restrictions on the directionality in which arguments need to be combined with, and model variability in that way.

But what does that mean for modeling the *effect* of word order variability - namely, its use as a structural indication of informativity? As Hoffman (1995a)(p.151ff) observes, all the possible orders that a particular category allows for could be compiled out, and the information structure of each of these orders could thus be captured lexically. However, such a formalism would not be able to capture the interpretation of adjunctions in different word orders or with long-distance scrambling. To overcome this problem, Hoffman proposes to split the grammar into two components: Lexical (linguistic) categories and combinatory rules to derive the predicate-argument structure of a sentence, and so-called Ordering categories together with application rules (and identity) to derive the information structure of a sentence.

Essentially, Ordering categories are templates of surface realizations of information structure, specifying where the focus, topic, and ground components of Hoffman's information structure need to be found in the surface form. Every word in the sentence is associated with a lexical category, which is then associated with an ordering category. The grammatical analysis of the sentence is an inference over lexical categories using MCCG's combinatory rules, and compositionally builds the underlying argument structure. In *parallel to* this inference, we have inference over the ordering categories (associated to words) that compositionally builds the sentence's underlying information structure. Hoffman defines her system such that the grammatical inference and the information structure inference control each other: Composition in one inference can only be done iff it is possible in the other inference. It is in this way, Hoffman argues, that "syntactic and pragmatic constraints work together to determine the surface structure and word order of the sentence." (1995a)(p.160)

However, compiling out possible information structure into Ordering categories is a rather "extensional" approach to explaining word order as a structural indication of informativity –necessitated by CCG's Principle of Adjacency– and raises doubts about the possibility of having multiple levels of linguistic information interact in realizing information structure. For example, Hoffman does discuss examples that illustrate how tune and word order interact to realize information structure, and shows how she can *represent* these information structures, yet there is no formulation of the actual inference mechanisms that would lead to these representations. Hoffman refers to Steedman's earlier work on tune, and argues that her approach is similar to his. Comparing (Hoffman, 1995a) to Steedman's recent (2000a) reveals that there is a substantial difference, though, nowadays. Steedman considers separate prosodic categories and lexical categories, but the effect of the prosodic categories is a specification of an INFORMATION feature on lexical categories. Hence, Steedman can use a singular set of inference rules that lets information structure reflect directly in the predicate-argument structures.[19]

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[19] Consider though that the effect of a prosodic Theme category on a lexical category like $(S_\iota \backslash NP_\iota)/_\iota NP$ is just the specification of the information feature ι to "Theme" (θ), i.e. the lexical category becomes $(S_\iota \backslash NP_\theta)/_\theta NP$. "Unification" of a lexical category with an ordering category, if one were to go that way, is an entirely different issue than just a specification of features.

As with any such extensional approach, it can be doubted that this would provide us with a flexible enough setting to capture complex phenomena. And, aside from the issue whether it is technically elegant to discern separate categories for different levels of linguistic information, it does not seem to lend itself very well to cross-linguistic generalizations. In CCG, it is the combinatory rules that help us specify cross-linguistic patterns, not the categories (Steedman, 2000c; Kruijff and Baldridge, 2000) - but in the only existing combinatory account of word order and information structure (Hoffman, 1995a) the description of the realization of information structure is decoupled from the syntactic inference.

To recapitulate, the notions of information structure that FGD and Steedman propose are similar, and are not subject to the problems we can note for information packaging. FGD and Steedman differ in the way they describe information structure and its realization. Theoretically, FGD can be understood to argue for the realization of information structure as an interaction between different means, like tune and word order. They are all parameters in the realization – though we can question in how far it is possible to achieve this interaction *technically* in a transformational approach. The combinatory tradition has yielded various formalizations that show how either word order (Hoffman, 1995a) or tune (Steedman, 2000a; Steedman, 2000c) can be related to information structure. However, we can question whether the theoretical background leads to descriptions of information structure and its realization that are linguistically intuitive and generalizable across different types of languages. CCG's Principle of Adjacency seems to necessitate a formal dissociation of the description of word order from the description of information structure, which breaks with the general linguistic intuition behind word order as a structural indication of informativity.

5.6 Information structure in DGL

DGL combines the best of two worlds - FGD's view on information structure and its realization as an interaction between different means, and the categorial approach to formalizing the relation between surface form and underlying linguistic meaning. However, unlike CCG we take adjacency to be a *parameter* (Moortgat and Oehrle, 1994) – a parameter determined for an important part by its purpose as a structural indication of informativity. Chapter 7 shows how this leads not only to a *direct* (rather than dissociated) explanation of word order as a structural indication of informativity, but also to an approach that is generalizable cross-linguistically. Chapter 8 proposes a reformulation of (part of) Steedman's description of tune, and shows how it can be smoothly integrated into the account of word order – without any need for distinguishing additional levels of categories. In the remainder of this chapter we present the basic definitions for representing and interpreting information structure.

Definition 18 (Representing contextual boundness). *DGL distinguishes four types of contextual boundness: CB and NB, CB* and NB*. CB* corresponds to (Hajičová et al., 1998)'s c marker or Steedman's Theme-focus. NB* corresponds to the focus proper (Sgall et al., 1986) or Steedman's Rheme-focus. These types are represented at the level of linguistic meaning as* $[\cdot]$ *unary operators, and are reflected as* $\Box^{\downarrow}.$ *in categories. Formally, they are specifications of an underspecified feature* inf. $\circledast$

Remark 16. A lexical category usually only specifies the informativity of the word as inf. Its informativity feature gets specified in the process of derivation, the basic mechanisms of which we already discussed in Chapter 4. Due to the correspondence between operations on categorial features and their reflection in the underlying linguistic meaning, determination of a feature due to its occurrence in a structural configuration (e.g. word order, tune) means that this is noted in the linguistic meaning as well. For example, Chapter 7 shows how we can derive a fully specified structure $(\langle \text{Honza}\rangle^{cb} \circ_{\prec sc} \text{snědl}) \circ_{dc\succ} \langle \text{koblihu}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{cb} S$, given lexical entries that just specify inf like snědl $\vdash \Box^{\downarrow}{}_{inf}((S\backslash_{\prec sc}\Diamond_{Actor}N)/_{dc\succ}\Diamond_{Patient}N)$. The corresponding linguistic meaning is $@_h([\text{NB}](\mathcal{E} \wedge \textbf{eat}) \wedge [\text{CB}]\langle \text{ACTOR}\rangle(j \wedge \textbf{honza}) \wedge [\text{NB}]\langle \text{PATIENT}\rangle(d \wedge \textbf{donut}))$. $\circledast$

Definition 19 (Topic/focus articulation in DGL). *Like in FGD, a sentence's topic-focus articulation is derived recursively from the indication of informativity of the individual nodes in that sentence's linguistic meaning. To establish the topic and the focus of a sentence, we use rules that rewrite a logical formula just indicating contextual boundness to a logical formula including a topic/focus partition* $\mathcal{T} \bowtie \mathcal{F}$ *(Kruijff-Korbayová, 1998). The idea of using rewriting stems from Oehrle (1999), but the recursion the* *rules implement is essentially Sgall et al's procedure (cf. page 160) with the amendments of (Hajičová et al., 1998)(p.164).*

Formally, we represent a topic/focus partition as $@_h(T \bowtie F)$. *T and F are conjunctions of terms, whereby T may be empty (in which case we write* $\top$*). By definition, F must not be empty; if at one point we obtain an empty focus, we write that* $\bot$*, and try to find a deeper embedded NB element to serve as focus. A rewrite rule is stated as* $\mathcal{R}(\phi \mapsto \psi)$*, rewriting* ϕ *into* ψ*. Note that containment* $\Gamma[\cdot]$ *is not recursive here, but only to the current level of conjunction.*

(326) *If a verbal head of the clause is CB, then it belongs to the topic.*
$\mathcal{R}(@_h([\textsc{cb}](\mathcal{E} \wedge \phi) \wedge \Phi) \mapsto @_h([\textsc{cb}](\mathcal{E} \wedge \phi) \bowtie \Phi))$

(327) *If a verbal head of the clause is NB, then it belongs to the focus.*
$\mathcal{R}(@_h([\textsc{nb}](\mathcal{E} \wedge \phi) \wedge \Phi) \mapsto @_h(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \phi) \wedge \Phi))$

(328) *If a dependent* δ *of a verbal head is CB, then* δ *belongs to the topic (including any nodes it governs).*
$\mathcal{R}(@_h(\Phi \bowtie [\textsc{cb}]\delta \wedge \Psi) \mapsto @_h([\textsc{cb}]\delta \wedge \Phi \bowtie \Psi))$

(329) *If a dependent* δ *of a verbal head is NB, then* δ *belongs to the focus (including any nodes it governs).*
$\mathcal{R}(@_h(\Phi \bowtie [\textsc{nb}]\delta \wedge \Psi) \mapsto @_h(\Phi \bowtie \Psi \wedge [\textsc{nb}]\delta))$

(330) *If a CB dependent of type* δ *is an embedded clause, then it should be placed first (topic proper).*
$\mathcal{R}(@_h(\Phi[[\textsc{cb}]\langle\delta\rangle(\Gamma[(\mathcal{E} \wedge \pi)])] \bowtie \Psi) \mapsto @_h([\textsc{cb}]\langle\delta\rangle(\Gamma[(\mathcal{E} \wedge \pi)]) \wedge \Phi \bowtie \Psi)$

(331) *If a NB dependent of type* δ *is an embedded clause, then it should be placed last (focus proper).*
$\mathcal{R}(@_h(\Phi \bowtie \Psi[[\textsc{nb}]\langle\delta\rangle(\Gamma[(\mathcal{E} \wedge \pi)])])) \mapsto @_h(\Phi \bowtie \Psi \wedge [\textsc{nb}]\langle\delta\rangle(\Gamma[(\mathcal{E} \wedge \pi)])))$

(332) *Embedded focus: If in* $\Phi \bowtie \Psi$, Ψ *contains no inner participants* ($\delta \in \{$Actor, Patient, Addressee, Effect, Origin $\}$*) whereas* Φ *does, then a NB modification of a CB dependent is part of the focus:*
$\mathcal{R}(@_h(\Phi[[\textsc{cb}]\langle\delta\rangle(\Gamma[[\textsc{nb}]\langle\delta'\rangle(d \wedge \Delta)])] \bowtie \Psi) \mapsto$
$\mapsto @_h(\Phi[[\textsc{cb}]\langle\delta\rangle(\Gamma[])] \bowtie [\textsc{cb}]\langle\delta\rangle[\textsc{nb}]\langle\delta'\rangle(d \wedge \Delta) \wedge \Psi))$

A valid topic-focus articulation is a structure $\Phi \bowtie \Psi$ *to which we can no longer apply any of the rewrite rules given in (326) through (332), and where* $\Psi \neq \bot$.

$\circledast$

Remark 17 (The structure of information structure). What kinds of structures do we obtain using Definition 19? Abstractly, what we obtain is a relational structure where the relate may be distributed across the $\bowtie$ operator, while maintaining their mutual relations through nominal reference.

Applying the rules given in Definition 19, we obtain the topic/focus bipartitioning as presented in (333).

(333) **English**

The cat ate a SAUSAGE.

i. $@_h([\textsc{nb}](\mathcal{E} \wedge \mathbf{eat}) \wedge [\textsc{cb}]\langle \textsc{Actor}\rangle(c \wedge \mathbf{cat}) \wedge [\textsc{nb}]\langle \textsc{Patient}\rangle(s \wedge \mathbf{sausage}))$

ii. (327),$@_h(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{eat}) \wedge [\textsc{cb}]\langle \textsc{Actor}\rangle(c \wedge \mathbf{cat}) \wedge [\textsc{nb}]\langle \textsc{Patient}\rangle(s \wedge \mathbf{sausage}))$

iii. (328),$@_h([\textsc{cb}]\langle \textsc{Actor}\rangle(c \wedge \mathbf{cat}) \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{eat}) \wedge [\textsc{nb}]\langle \textsc{Patient}\rangle(s \wedge \mathbf{sausage}))$

$\circledast$

We also obtain the desired topic-focus articulation for examples like (334):

(334) **English**

I met the teacher of CHEMISTRY.

i. $@_h([\textsc{cb}](\mathcal{E} \wedge \mathbf{meet}) \wedge [\textsc{cb}]\langle \textsc{Actor}\rangle(i \wedge \mathbf{I})$
$\wedge [\textsc{cb}]\langle \textsc{Patient}\rangle(t \wedge \mathbf{teacher} \wedge [\textsc{nb}]\langle \textsc{Appurtenance}\rangle(c \wedge \mathbf{chemistry})))$

ii. (326),$@_h([\textsc{cb}](\mathcal{E} \wedge \mathbf{meet}) \bowtie [\textsc{cb}]\langle \textsc{Actor}\rangle(i \wedge \mathbf{I})$
$\wedge [\textsc{cb}]\langle \textsc{Patient}\rangle(t \wedge \mathbf{teacher} \wedge [\textsc{nb}]\langle \textsc{Appurtenance}\rangle(c \wedge \mathbf{chemistry})))$

iii. (328), $@_h([\textsc{cb}](\mathcal{E} \wedge \mathbf{meet}) \wedge [\textsc{cb}]\langle \textsc{Actor}\rangle(i \wedge \mathbf{I})$
$\bowtie [\textsc{cb}]\langle \textsc{Patient}\rangle(t \wedge \mathbf{teacher} \wedge [\textsc{nb}]\langle \textsc{Appurtenance}\rangle(c \wedge \mathbf{chemistry})))$

iv. (328), $@_h([\textsc{cb}](\mathcal{E} \wedge \mathbf{meet}) \wedge [\textsc{cb}]\langle \textsc{Actor}\rangle(i \wedge \mathbf{I})$
$[\textsc{cb}]\langle \textsc{Patient}\rangle(t \wedge \mathbf{teacher} \wedge [\textsc{nb}]\langle \textsc{Appurtenance}\rangle(c \wedge \mathbf{chemistry})) \bowtie \bot)$

v. (332), $@_h([\textsc{cb}](\mathcal{E} \wedge \mathbf{meet}) \wedge [\textsc{cb}]\langle \textsc{Actor}\rangle(i \wedge \mathbf{I})$
$[\textsc{cb}]\langle \textsc{Patient}\rangle(t \wedge \mathbf{teacher}) \bowtie [\textsc{cb}]\langle \textsc{Patient}\rangle[\textsc{nb}]\langle \textsc{Appurtenance}\rangle(c \wedge \mathbf{chemistry}))$

$\circledast$

The rewriting in (334) relies crucially on the rule that handles embedded foci, (332). The formulation of this rule is 'different' from (Sgall et al., 1986), in the sense that it is a generalization similar to proposals in Koktová (1995). The rewrite rule (332) enables us to deal properly with examples like (335), which are answers to so-called *double-focus questions*.

(335) **English**
(Whom did you give what book?)
I gave the book on SYNTAX to KATHY.

(336) i. $@_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\wedge [\textsc{nb}]\langle\textsc{Addressee}\rangle(k \wedge \textbf{Kathy}))$

ii. $(326), @_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \bowtie [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\wedge [\textsc{nb}]\langle\textsc{Addressee}\rangle(k \wedge \textbf{Kathy}))$

iii. $(328), @_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\bowtie [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\wedge [\textsc{nb}]\langle\textsc{Addressee}\rangle(k \wedge \textbf{Kathy}))$

iv. $(328), @_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\bowtie [\textsc{nb}]\langle\textsc{Addressee}\rangle(k \wedge \textbf{Kathy}))$

v. $(332), @_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book}) \bowtie [\textsc{cb}]\langle\textsc{Patient}\rangle[\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax})$
$\wedge [\textsc{nb}]\langle\textsc{Addressee}\rangle(k \wedge \textbf{Kathy}))$

$\circledast$

Moreover, we can combine examples like (334) and (336) to form (337). Also (338) can be analyzed, in a straightforward way. Note that information packaging does not seem to be able to analyze (337). It is not entirely clear what Steedman's treatment of (337) would be like.

(337) **English**
(Which teacher did you give what book?)
I gave the book on SYNTAX to the teacher of ENGLISH.

(338) i. $@_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\wedge [\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English})))$

ii. $(326), @_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \bowtie [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\wedge [\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English})))$

iii. $(328), @_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\bowtie [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$

$\wedge\ [\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English})))$

iv. (328), $@_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$\bowtie\ [\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English})))$

v. (328), $@_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$
$[\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English}))\ \bowtie\ \bot)$

vi. (332), $@_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I}) \wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book})$
$[\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher} \wedge [\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English}))$
$\bowtie\ [\textsc{cb}]\langle\textsc{Patient}\rangle[\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax}))$

vii. (332), $@_h([\textsc{cb}](\mathcal{E} \wedge \textbf{give}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(i \wedge \textbf{I}) \wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \textbf{book})$
$[\textsc{cb}]\langle\textsc{Addressee}\rangle(t \wedge \textbf{teacher})\ \bowtie\ [\textsc{cb}]\langle\textsc{Patient}\rangle[\textsc{nb}]\langle\textsc{Appurtenance}\rangle(s \wedge \textbf{syntax})$
$\wedge\ [\textsc{cb}]\langle\textsc{Addressee}\rangle[\textsc{nb}]\langle\textsc{Appurtenance}\rangle(c \wedge \textbf{English}))$

$\circledast$

To recapitulate, the topic/focus structures we obtain in DGL are -still- relational structures. Nominals ensure that dependents and heads remain properly linked - which is exactly the heart of the problem in a typed approach like (Kruijff-Korbayová, 1998) when we get to very complex structures like (338). Like in TF-DRT, though, we connect the sentence's topic and focus using the $\bowtie$-operator. Following dynamic approaches to interpretation of information structure (like Kruijff-Korbayová's, Peregrin's or Steedman's), the $\bowtie$-operator controls how the sentence is interpreted in context given its information structure. Given a hybrid logical formula of the form $T \bowtie F$, we interpret the formula by *first* evaluating T against the current (discourse) model. Only if T can be interpreted, we interpret F. Chapter 9 discusses this in more detail, providing model-theoretic interpretations of CB,CB*, NB, and NB* and the described dynamic effect of $\bowtie$.
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Remark 18 (The relation to FGD). In the light of the above discussion, how does DGL's account of information structure relate to FGD's topic-focus articulation? Like I already pointed out at various points in the discussion, the account given here stays close to FGD, elaborating it where needed. The main difference with FGD is that in DGL the nodes in a linguistic meaning are not ordered according to communicative dynamism. Sgall et al (1986)(p.220ff) discuss their interpretation of Firbas's notion of communicative dynamism, and argue for the semantic relevance of communicative dynamism. Communicative dynamism can be related to degrees of salience, and is thus arguably relevant for contextual interpretation in general the interpretation of quantifier scope in particular (cf. also (Hajičová et al., 1998)(pp.158-159)). Because I deal neither with quantifiers nor focalizers, and because the notion of communicative dynamism is still in need of further development (Hajičová et al., 1998), I have not included it in DGL. At the same time, that is not to say that DGL *could not* provide the basis for a formal account of communicative dynamism.

The idea of communicative dynamism as an ordering over the nodes in a representation of sentential linguistic meaning could be incorporated in DGL along the following lines. In the elimination of a slash or a product, a $\wedge$ is introduced into the linguistic meaning to combine the function and the argument. We can first of all refine this by saying that the elimination of $\{\backslash_\mu, /_\mu, \bullet_\mu\}$ introduces a connective $\wedge^\mu$. Furthermore, following Sgall et al's proposals, we can relate surface word order to the ordering of nodes in the underlying linguistic meaning. This we can easily obtain, by first letting the underlying order mirror *finally obtained* order, and then ensuring that clitics and topical/focal embedded clauses are properly ordered. The latter ordering we can achieve because constructions involving clitics or embedded clauses are indicated by the use of particular modes, and these modes are reflected on the $\wedge$'s.

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SUMMARY

In this chapter I discussed FGD's theory of topic-focus articulation, Vallduví's information packaging, and Steedman's Theme/Rheme-based theory. All these theories have in common that they describe information structure in terms of its realization ("syntax") as well as its interpretation ("semantics") – contrary to many other approaches that consider just one or the other. In reflection on these theories, I noted several problems. I argued that information packaging is mistaken in its conflation of thematic structure and information structure, showing examples that it cannot satisfactorily explain. Furthermore, its characterization of the primary notions of ground and focus as partitions of a sentence's *surface form* leads to problems with recursivity, and appears at odds with the generally accepted idea of information structure being an aspect of linguistic meaning. Finally, its relation to a concrete grammar framework is underdeveloped. It is not clear how the GB architecture of (Vallduví, 1990) or HPSG (Engdahl and Vallduví, 1994) could be extended to explain word order, tune and their interaction as means to realize to information structure.

For FGD and CCG we observed that their notions of information structure are closely related. However, they differ substantially in their views of grammar. FGD adopts a transformational approach to explain how information structure acts as a parameter determining word order and intonation. CCG is a monostratal formalism in which sufrace form and underlying meaning (with information structure) are compositionally related. For FGD I noted that a transformational account cannot give a principled account of how different strategies (like tune, word order, morphology) can *interact* to realize information structure. CCG has been extended to cover tune and variability in word order, but I argued that CCG's Principle of Adjacency seems to necessitate a formal dissociation of the descriptions of word order and of information structure. This breaks with the general linguistic intuition of word order as a structural indication of informativity.

Alike CCG, DGL is a monostratal, compositional approach. In DGL we operate on multidimensional signs that represent different levels of linguistic information, and there is no problem in letting different levels interact simultaneously (like in a transformational approach). Like FGD, I consider information structure as an important factor in determining surface realization, and I argued how we can formalize that view in DGL's parametrized setting (using modes and structural rules). I ended the chapter with discussing how information structure is represented at the level of linguistic meaning in DGL. Based on the proposals of (Sgall et al., 1986; Heycock, 1993; Hajičová et al., 1998; Steedman, 2000c) I consider a moderate form of recursivity of information structure. I explained how that enables us to cover complex examples involving double foci or embedded foci which e.g. information packaging is unable to explain.

CHAPTER 6

THE CATEGORY OF INFORMATIVITY

Information structure can be realized using various means - but when and why can (or does) a language avail itself of these means? In this chapter I discuss a basic typological characterization of when languages use variability in word order or tune as *strategies* to realize *informativity*, i.e. indications of contextual boundness. The characterization is based on empirical data from a variety of typologically different languages, and a new typology of variability in word order. The results of this chapter are a set of typological hypotheses predicting whether a language has rigid, mixed, or free word order, an informativity markedness principle, and a set of hypotheses that predict when languages use word order, tune or a combination thereof to realize information structure. These two sets of hypotheses form the typological basis for the grammar architectures to be presented in the next two chapters.

> *The doctrine seems to be that we derive aesthetic pleasure in comprehending something as a unified structure, in finding that a complex of disparate phenomena can be experienced as a unified whole.*
>
> – Christopher Hookway

6.1 INTRODUCTION

The goal in this chapter is to formulate a small set of hypotheses that *predict* when a language might use particular strategies to realize information structure, thus trying to characterize contextual boundness as a typological *category of informativity*. These hypotheses are based on empirical data from a variety of typologically different languages, and take tune and variability in word order into account.[1] These hypotheses form the typological basis for the grammar architectures to be presented in the next two chapters.

In this chapter we begin by discussing a typological perspective on word order. We start with basic or *dominant* word order in §6.2. There are two

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[1] We are aware of the fact that there are more means than variability in word order and tune. The hypotheses we present here provide a *basis*. We do not claim they are complete - they need to be tested on a larger amount of data, and elaborated where needed to cover more of the means mentioned in the introduction to Chapter 5.

reasons for doing that. Firstly, variability in word order is variation on dominant word order. Secondly, in a Lambek-style categorial grammar, any account of word order starts in the lexicon with assigning categories that model dominant word order.[2] Because work in typology has mainly focused on dominant word order, like Greenberg (1966) or Hawkins (1983), we can readily make use of their findings to formulate a *cross-linguistic* procedure to construct lexical categories for basic word classes. In other words, the typological perspective on word order starts in the lexicon, as one would expect in a categorial approach.

Subsequently, we turn to variability in word order in §6.3. Naturally, to be able to predict when a language can use variability in word order to realize information structure, we need to know to what extent that language can vary its word order. Unfortunately, there appears to be no typological account explaining when a language can display a particular degree of variability in word order, cf. (Croft, 1990; Lehmann, 1993; Ramat and Ramat, 1998). Steele (1978) discusses different degrees of word order (rigid, mixed and free) but provides no typological hierarchy on which one degree or another would be implied by some basic facts about the language. Skalička's work does discuss a typological characterization but only distinguishes between what Steele would term rigid and free word order, cf. (Skalička and Sgall, 1994; Sgall, 1995b). Here we combine Steele's characterization, Skalička's typology of languages, and observations on a variety of typologically different languages to construct an initial proposal for a typological characterization of rigid, mixed, and free word order variability. We need at least a three-way distinction of variability to be able to explain the different levels of interaction between tune and word order to realize information structure, as observable in languages like English (rigid), Dutch and German (mixed), or Czech and Turkish (free).

Finally, we propose several hypotheses that predict, for a language of a given type, what strategies it will use to realize information structure. The strategies we discuss here are based on word order, tune and their interaction. The hypotheses elaborate various predictions advanced by Sgall *et al.* (1986), and are illustrated on a number of typologically different languages. Following practice in language typology, we conceive of these hypotheses

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[2] Unlike the combinatory tradition, where lexical categories not only model dominant word order but also possible variability (Hoffman, 1995a; Baldridge, 1998).

as (initial) explanations of how strategies like word order or tune realize a *category of informativity.* In the next chapters, we formulate grammar architectures that model these strategies – the hypotheses formulated here control the accessibility of the rule packages modeling particular strategies.

6.2 BASIC WORD ORDER

The goal of this section is to construct a *representation* a typological model of *basic word order* in DGL. By "basic word order" we understand the placement of modifiers relative to their heads - subject and object as modifiers of a verbal head, and most nominal head modifiers. For example, if we look at the placement of subject, object, and verb in various languages, we can observe distinct orders. Three commonly found orders are SOV, SVO, and VSO, illustrated here in examples (339) through (341) respectively.[3]

(339) SOV (e.g. **Japanese**)

Taroo-ga	ringo-o	tabeta
Taroo-NOM	apple-ACC	ate

"Taroo at an apple."

(340) SVO (e.g. **English**)
Elijah read a book

(341) VSO (e.g. **Welsh**)

Lladdodd	y	ddraig	y	dyn
killed	the	dragon	the	man

"The dragon killed the man." (Comrie, (Hawkins, 1983)(p.1))

Besides a differentiation in how a language orders a verb and its complements, we can also observe variation in other orderings. For example, whereas Japanese uses *postpositions* like *kooen-**made*** (**English** "**to** the

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[3] The notions of 'Subject' and 'object' as grammatical roles need to be specified, as their use is occasionally confusing. Here, we adhere to the understanding proposed in Manning (1996) and Kroeger (1993), going back to Dixons' notion of "pivot". Both Manning and Kroeger use a characterization that applies to ergative languages as well, and argue that - even there- we can broadly understand the nominative verbal argument to be the subject. Kroeger discusses several tests that confirm this, these tests being applicable only to nominative arguments: Raising, Conjunction Reduction, Possessor Ascension, secondary predication, obviation, and number agreement (1993)(p.55). For more discussion, see (Manning, 1996) and (Kroeger, 1993).

park"), English uses *prepositions.*[4] Similarly, languages vary in where they place nominal modifiers like adjectivals, genitives, or relative clauses. As Hawkins remarks in (1983)(p.2), despite all this variation clear patterns can be discerned. Nineteen- and early-twentieth century German scholars were possibly the first to draw attention to them (Hawkins; cf. also (Sgall, 1995b)(p.52)), and the work by for example Greenberg, Lehmann, Venneman, and Hawkins can be seen as a continuation of their work.

In the next section we present the two hierarchies that Hawkins proposes to explain the basic word order of nouns and their modifiers. These hierarchies employ standard connectives from propositional logic to combine implicational universals into a concise statement of the interrelations between different factors determining basic word order. The noun/modifier hierarchies can be combined with universals describing the basic word order of the verb and its complements (primarily, subject and object), to cover the patterns leading to the 24 language types proposed by Greenberg and further explored by Hawkins and colleagues.

6.2.1 HAWKINS' TYPOLOGY OF BASIC WORD ORDER

Hawkins (1983) advances a typological model of basic word order that is based on the rich set of Greenberg's universals and which shares Venneman's concern with the head-dependent asymmetry.[5] There are several points on which Hawkins' model distinguishes itself, though.

For one, Hawkins argues that statistical implicational universals should be avoided, as they are "theoretically undesirable" (p.60). Instead, non-statistical implicational universals should be used, which are exceptionless. To show that one actually *can* construct an account of basic word order in terms of implicational universals, Hawkins builds his on a very large collection of data. He uses as a starting point Greenberg's 30-language sample, and the sample of 142 languages that Greenberg used for certain (limited)

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[4] Languages need not strictly use either prepositions or postpositions. For example, Dutch and German use both pre- and postpositions: **German** *das Haus* ***gegenüber*** (**English** "**opposite** to the house"), versus **German** ***auf*** *dem Haus* (**English** "**on** the house"). If a language allows for two otherwise "opposite" orderings, it can be said to be *doubling* (Hawkins, 1983). Doubling is often understood in terms of language change, with one strategy becoming outdated and making place for a new, dominant strategy.

[5] Greenberg (1966) also notes that the distinction between heads and modifiers is important to find an answer to why languages select one particular basic word order over another, but does not address the issue in detail.

co-occurrences of basic word order. Hawkins (and colleagues) extended the second sample to cover about 350 languages, and his typology of basic word order is based on the data presented by that sample.

Another point that distinguishes Hawkins from Greenberg and Venneman concerns the notion of "word order type". In Hawkins' typology, the notion of a word order type no longer means a uniform linearization for all different kinds of head/dependent constructions one might distinguish in a language. Instead, a "word order type" is defined as a specific pattern of co-occurrence possibilities permitted by the implicational universals that Hawkins defines. Each of these patterns contains a common shared property, like 'prepositions', functioning as the typological indicator (1983)(pp.114-115). Word order types are thus no longer tied to either XV or VX, since correlations to *only* these word order patterns do not always give rise to explanations *why* other regularities *do* occur. Rather than taking XV or VX (or Greenberg's VOS, SVO, SOV), the *entire* pattern defines the word order type. And, because the pattern is considered as a whole, it is possible to say what parts, what particular co-occurrences, make it unique. Obviously, this leads to more precise generalizations.

Against this background[6], Hawkins presents a set of basic word order universals that extends Greenberg's original classification. From these universals, Hawkins derives two hierarchies for noun modifiers - the *Prepositional Noun Modifier Hierarchy* (342), and the *Postpositional Noun Modifier Hierarchy* (343). (*N* indicates the nominal head, *A* the adjective, *G* the genitive.)

(342) Universal XIV, *Prepositional Noun Modifier Hierarchy*
Prep $\supset$ ((NDem $\vee$ NNum $\supset$ NA) & (NA $\supset$ NG) & (NG $\supset$ NRel))

(343) Universal XVIII, *Postpositional Noun Modifier Hierarchy*
Postp $\supset$ ((AN $\vee$ RelN $\supset$ DemN & NumN) & (DemN $\vee$ NumN $\supset$ GN))

These hierarchies can be combined with universals on the relation between noun-modifier word order and the basic word order of the verb and its complements (primarily, subject and object) to explain the patterns lead-

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[6] For completeness, we should also mention that Hawkins introduces two competing principles to explain the basic word order of nouns and their modifiers. These principles are the Heaviness Hierarchy and the Mobility Principle. As the discussion of these principles is not directly relevant to our argument here, we refer the interested reader to (Hawkins, 1983).

ing to the 24 language types proposed by Greenberg (and further explored by Hawkins and colleagues). We will not discuss the full set of basic word order types discussed in (Greenberg, 1966; Hawkins, 1983). Instead, we briefly point out how we can use these basic word order types to construct lexical categories. That way, we start our cross-linguistic account of word order already in the lexicon, as appropriate for a lexicalized approach like categorial grammar.

6.2.2 A TYPOLOGICAL MODEL OF BASIC WORD ORDER IN DGL

The aim in the current section is to relate Hawkins' typology of basic word order to a grammar framework like DGL. Because DGL is a categorial grammar, this is relatively simple: The ordering given by the typology translates more or less directly into the directionality of the slashes that we use in categories assigned to different word classes in the lexicon.

The approach is simple, but not *simplistic*: It is simple because of the categorial nature of the approach. The approach is far from simplistic since in a categorial grammar the grammar is for a fundamental part constituted by the lexicon. The predictions that the typology makes can thus be couched *in terms of cross-linguistic (architectures for) grammar fragments.* In relation to the discussion in Chapter 4, we extend the mapping S in DGL's linking theory, Definition 14 on page 131.[7]

To reflect the distinctions that Hawkins' typology of basic word order makes, we distinguish different *modes*. The relevant modes are given in (344-346). Modes may be *headed*, as indicated. As we explained in Chapter 4, following (Hepple, 1997), a headed mode explicitly indicates where the head of the construction is. Thus, in $A \circ_{m\succ} B$ mode m is a headed mode, with the arrow $\succ$ pointing *to* the dependent B *away* from the head A. Logically, this means that a headed mode m has associated to it *two* products: $\prec m = \{\circ_{\prec m}, \backslash_{\prec m}, /_{\prec m}\}$ and $m \succ = \{\circ_{m\succ}, \backslash_{m\succ}, /_{m\succ}\}$.

(344) VERBAL MODIFIERS:

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[7] Again, the proposal here does not pretend to be empirically complete. The point here is to show that we can use the findings of language typology in a (categorial) grammar framework – in spirit similar to (Venneman, 1977), but significantly improving on his proposal by making use of (Hawkins, 1983). Because we are interested in the realization of information structure, we pay more attention to variability in word order rather than basic word order. The discussion of basic word order is provided to start a cross-linguistic discussion of word order in (for categorial grammar) the proper place – the lexicon.

Name	**Form**	**App.**	**Description**
Subject	*sc*	Verb	Marks the subject position.
Direct complement	*dc*	Verb	Marks the direct complement position.
Indirect complement	*idc*	Verb	Marks the indirect complement position.
Complement	*c*	Verb, Noun	Composition with a complement.
Temporal adjunct	*tma*	Verb, Noun	Composition with a temp. adj.
Spatial adjunct	*spa*	Verb, Noun	Composition with a spatial adj., *headed*

(345) NOMINAL MODIFIERS:

Name	**Form**	**App.**	**Description**
Adjectival	*adj*	Adjective	Composition of noun with adjective.
Genitival	*gen*	Noun	Composition of noun with genitival.
Complement	*c*	Verb, Noun	Composition with a complement.
Temporal adjunct	*tma*	Verb, Noun	Composition with a temp. adj.
Spatial adjunct	*spa*	Verb, Noun	Composition with a spatial adj., *headed*
Demonstrative	*dem*	Noun	Composition of noun with demonstrative, *headed*
Article	*art*	Noun	Composition of noun with article.

(346) ADJECTIVAL/ADVERBIAL MODIFIERS:

Name	**Form**	**App.**	**Description**
Adjectival	*adj*	Adjective	Composition of noun with adjective.
Adverbial	*adv*	Adverbial	Marks construction with adverbial.

In (347) we define the categories for transitive verbs, for active voice. We leave out intransitive and ditransitive verbs, as the categories for these verbs can be immediately derived from the specifications in (347).

(347) VERB, SUBJECT, OBJECT (ACTIVE VOICE):

$$\text{Verb category} = \begin{cases} \Box^{\downarrow}{}_{actv}((S\backslash_{\prec sc}\Box^{\downarrow}{}_{act}N)/_{dc\succ}\Box^{\downarrow}{}_{pat}N) & SVO \\ \Box^{\downarrow}{}_{actv}((S/_{dc\succ}\Box^{\downarrow}{}_{pat}N)/_{sc\succ}\Box^{\downarrow}{}_{act}N) & VSO \\ \Box^{\downarrow}{}_{actv}((S\backslash_{\prec dc}\Box^{\downarrow}{}_{pat}N)\backslash_{\prec sc}\Box^{\downarrow}{}_{act}N) & SOV \end{cases}$$

Next, (350) and (351) specify the categories for adjectival and *general* genitival modifiers of nominal heads, respectively. The genitival categories are general in that they only hold for what could be called *bare* genitival structures, being constructions that are *not* construed using a function word. An example of what we understand by such bare constructions are given in (348), with "non-bare" constructions illustrated in (349).

(348) **English**
(Kathy's)$_{bare-gen}$ book

(349) **English**
the book (of the lecturer)$_{gen}$

(350) Adjective, Nominal head modification:

$$\text{Adjective category} = \begin{cases} (N/_{\prec adj}N) & AN \\ (N\backslash_{adj\succ}N) & NA \end{cases}$$

(351) Genitive, Nominal head modification:

$$\text{Genitive category} = \begin{cases} (N/_{\prec gen}N) & GN \\ (N\backslash_{gen\succ}N) & NG \end{cases}$$

(352) Demonstrative, Nominal head modification:

$$\text{Demonstrative category} = \begin{cases} (N/_{\prec dem}N) & DemN \\ (N\backslash_{dem\succ}N) & NDem \end{cases}$$

(353) Hypothesis: Prep & DemN ⊃ ArtN

(354) Article, Nominal head modification:

$$\text{Article category} = \begin{cases} (\Box^{\downarrow}{}_{def}N/_{\prec art}\Box^{\downarrow}{}_{det}N) & Definite\ article, DemN \\ (\Box^{\downarrow}{}_{def}N\backslash_{art\succ}\Box^{\downarrow}{}_{det}N) & Definite\ article, NDem \\ (\Box^{\downarrow}{}_{indef}N/_{\prec art}\Box^{\downarrow}{}_{det}N) & Indefinite\ article, DemN \\ (\Box^{\downarrow}{}_{indef}N\backslash_{art\succ}\Box^{\downarrow}{}_{det}N) & Indefinite\ article, NDem \end{cases}$$

In the next section I look at variability in basic word order- thus, what possibilities are available in a language to alter the dominant word order specified by lexical categories.

6.3 Variability in (basic) word ordering

In this section a preliminary account of variability in word order is presented. Using a data sample of 22 languages, I try to establish hypotheses that take the form “If a language L has characteristics C,C’,... then it has a rigid/mixed/free word order.” Because the data sample is rather small, I do not claim the hypotheses to be anything more than just that - hypothetical explanations that are hopefully verified (with minimal adaptation) in the long run.

The typological literature is rather sparse on accounts of *why* languages vary in word order flexibility. In the literature (e.g. (Croft, 1990)), Steele’s (1978) is cited as the reference on variation in word order, focusing on word order of the matrix clause.[8] Steele proposes a distinction of three degrees

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[8] As we already saw above, Greenberg (1966) and Hawkins (1983) focus rather on basic word order rather than on variation. Most later typological discussions do not discuss

of word order freedom, being rigid, mixed and free, but does not present a typological characterization of when one of these degrees is available in a language. Within the Prague School of Linguistics, Skalička's account of language types (cf. Skalička and Sgall's (1994), Sgall's (1995b) for a recent formulation) discusses the relation between morphology and variability in word order in more detail than found elsewhere, but only considers the opposition between rigid and free word order.

The account I present is based on Steele's characterization of variation (i.e. when a language's word order is rigid, mixed, or free) and, for an important part, on Skalička's insights. Particularly, the initial data gathering was done with the following null hypothesis in mind:

(355) WORD ORDER NULL HYPOTHESIS: The more a language allows for the following phenomena to occur grammatically, the higher the likelihood that the language has a relatively free word order: frequent use of null anaphora, lack of expletive pronouns, a rich case system, complex verbal morphology.

This null hypothesis follows from Skalička's work on language types, Sgall *et al.*'s comments in (1986), and from work by Hale and by Speas as referred to in (Kroeger, 1993)(p.113). The hypotheses I formulate on the basis of the data work out the null hypothesis in more detail. The intention with these hypotheses is to come to a characterization of variability in word order on the basis of formal aspects of a language. At least to the extent allowed by the relatively small and eclectic sample we present here, the hypotheses purport to explain *why* each of these languages displays a particular (in)flexibility in word order.[9]

For 20 languages I gathered data about the following aspects.[10] The

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variation of word order in any depth either - cf. (Ramat and Ramat, 1998), (Lehmann, 1993).

[9] A null hypothesis like (355) is by no means universally accepted as a good ground for trying to explain when variability in word order is possible at all (and could thus be used to realize information structure). For example, Steele seeks to explicitly rebuke such null hypotheses, and tries to correlate word order freedom with person-agreement between the subject and the verb. However, it is not clear in how far this would be supported by ergative languages. Moreover, if we want to extent the account of word order freedom to embedded clauses, Steele's suggestion is falsified by Turkish. As (Hoffman, 1995a) points out, there is no agreement between the verb and its subject of an embedded clause.

[10] In alphabetical order, the data comprises these languages: Biblical Hebrew (Ofir Zussman), Brazilian Portuguese (Fernanda Aranha, Jason Baldridge), Czech (Ivana Kruijff-Korbayová), Dutch (author), English (author, Mark Steedman), French (author, Mark

table in Figure 6.1 (page 202) presents the data.

Word order type: The Greenberg/Hawkins characterization of the language in terms of the relative ordering of verb, subject and object; genitives (G) and nominal heads (N); adjectives (A) and nominal heads (N); and whether the language is prepositional (Pr) or postpositional (Po).

Variation: The characterization of a language's word order (matrix clauses, dependent clauses) as *rigid*, *mixed* or *free*. To determine variation, we use Steele's proposal as in (1978): Of the constraints given below, if a language breaks constraint A (and hence A'), and B, then its word order is free, whereas its word order is rigid if none are broken. If some but not all constraints are broken, word order is mixed.

A. A variation on the basic word order in which the verb occurs in other than its position in the basic word order is to be avoided.[11]

A'. A variation on the basic word order in which the verb occurs either initial or final to the clause is to be avoided, if the verb was neither initial nor final respectively in the basic order.

B. A variation on the basic word order in which the object precedes the verb and the subject follows the verb is to be avoided.

Case strategies: Following Croft's discussion of morphological strategies in (1990) (cf. also Chapter 4), a specification of the strategies used for grammatical roles (primarily, subject and direct object) and for nominal modifiers. In the table in Figure 6.1, the columns 5-7 labelled *Case, Pos, Tune* relate to morphological strategies for verbal arguments, and columns 8-17 relate to morphological strategies for nominal modifiers.

Articles, expletives, and pro-drop: Inspired by Hale and by Speas (cf. (Kroeger, 1993)(p.113)), Skalička (Skalička and Sgall, 1994), and Sgall *et al.*'s remarks in (1986), we check whether a language has *both* definite and indefinite articles, whether it has expletives, and whether it allows the subject (and possibly other modifiers) to be dropped. The basic hypothesis

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Steedman), German (author, Julia Hockenmaier), Modern Greek (Nikiforos Karamanis), Modern Hebrew (Ofir Zussman, Nissim Francez, Shuly Winter), Hindi (Shravan Vasishth), Italian (Malvina Nissim), Japanese (Tomotsugo Kondo, Shravan Vasishth), Korean (Kihwang Lee), Mandarin (Julia Hockenmaier), Russian (Sofya Malamud), Swedish (Elisabet Engdahl, Natalia Modjeska-Nygren), Tagalog (Jason Baldridge), Turkish (Hoffman, 1995a).

[11] We understand "to be avoided" to mean that if the order would be grammatically *possible*, it would be highly marked.

is that the absence of articles and expletives, and the possibility to drop subjects, are all indicative of a rich case system, which usually enables a relatively free word order, cf. (Sgall, 1995b).

Verbal morphology: Skalička's language types relate a rich verbal morphology to freer word order. Here, we indicate what aspects of verbal morphology (like tense, aspect, modality, etc.) are marked on the verb itself. The remaining aspects are usually realized using auxiliaries (if at all present; e.g. Tagalog appears to miss tense, cf. (Kroeger, 1993)).

Agreement: In keeping with Steele's suggestion that there is a relation between free word order and Person-agreement between subject and verb, we check what a verb can (or does) agree with in each language.

To explain the variation in word order we observed in the data in Figure 6.1, we formulate a set of *variation hypotheses*. The variation hypotheses are formulated like implicational universals, with the exception that they use the connective $\Supset$ to indicate that the implication is hypothetical, and not universal. Furthermore, we define the logical relations between free, mixed, and rigid word order as follows: $\neg\mathsf{free} \equiv \mathsf{rigid} \vee \mathsf{mixed}$, $\neg\mathsf{mixed} \equiv \mathsf{rigid} \vee \mathsf{free}$, and $\neg\mathsf{rigid} \equiv \mathsf{mixed} \vee \mathsf{free}$.[12]

To make the representation of variation hypotheses more compact, we use a few useful abbreviations. $\mathsf{Strat(X,Y)}$ indicates that strategy Y is used to realize X. For example, $\mathsf{Strat(SubjObj,Pos)}$ means that positioning is used as a strategy to indicate the subject and the object of a verb. $\mathsf{VerbForm(X)}$ means that the verbal form inflects for X, $\mathsf{Art(K)}$ indicates an article of type K, and $\mathsf{Agr(X,Y)}$ indicates agreement between X and Y. Otherwise, we directly use the characteristics mentioned in the table in Figure 6.1. Negating a characteristic means it is not present (-), e.g. $\neg\mathsf{Drop}$ means a language is not pro-drop.

Then, on the basis of the data for OV languages in Figure 6.1 (i.e. Hindi, Hungarian, Japanese, Korean, and Turkish) we can formulate the variation hypotheses as in (356). These variation hypotheses specify when a language

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[12] In the long run, we expect there to be more of a *scale* of variability, rather than a discrete tripartition into rigid, mixed, and free.

Language	*WO type*	*G/H*	*Var.*	*Case*	*Pos*	*Tune*	*Case*	*Comp*	*Jux*	*Agr*	*Sup*	*Adp*	*Lnk*	*L+Ad*	*S+Ad*	*Afx*	*Art.*	*Expl.*	*Drop*	*Verb.*	*Agr.*
Bibl. Hebrew	VSO/Pr/NG/NA	1	R/R	Acc	+	-	-	-	-	+	-	+	-	-	-	+	def	-	+	PGN/T	Abs:S
Tagalog	V1/Pr/NG/NA V1/Pr/NG/AN	1 2	F/?	+	-	-	+	-	-	-	-	-	+	-	-	-	+	-	+	Pl/VA	Erg:A Abs:S
French	SVO/Pr/NG/NA	9	R/R	-	+	-	-	-	-	+	+	+	-	-	-	-	+	+	-	PGN/TA	Abs:S
M. Hebrew	SVO/Pr/NG/NA	9	R/R	Acc	+	-	-	-	-	+	-	+	-	-	-	+	def	-	+	PGN/T	Abs:S
Italian	SVO/Pr/NG/NA	9	R/R	-	+	-	-	-	-	+	+	+	-	-	-	-	+	-	+	N/T	Abs:S
English	SVO/Pr/NG/AN SVO/Pr/GN/AN	10 11	R/R	-	+	-	-	-	-	-	+	+	+	+	+	-	+	+	-	N/Pst	Abs:S Abs:S
Mandarin	SVO/Pr/GN/AN	11	R/R	Acc	+	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-
Swedish	SVO/Pr/GN/AN	11	R (V2)/R	-	+	-	-	-	-	+	+	+	+	+	-	+	+	+	-	NG/Pst	Abs:S
Dutch	SVO/Pr/NG/AN	10	M (V2)/R	-	+	-	-	-	-	-	+	+	+	-	+	-	+	+	-	N/Pst	Abs:S
German	SVO/Pr/NG/AN	10	M (V2)/M	+	+	-	+	-	-	+	+	+	+	-	+	-	+	+	-	N/Pst	Abs:S
Inuit	ErgAbsV/Po/ GN/AN	?	F/M	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	PN/TM	Erg:A Abs:S
Czech	SVO/Pr/NG/AN	10	F/F	+	-	-	+	-	-	+	-	+	-	-	-	-	-	-	+	PNG/TA	Abs:S
Russian	SVO/Pr/NG/AN	10	F/F	+	-	-	+	-	-	+	-	+	-	-	-	-	-	-	+	PNG/TA	Abs:S
M. Greek	SVO/Pr/NG/NA	9	F/F	+	-	-	+	-	-	+	-	-	-	-	-	-	+	-	+	NP/PstA	Abs:S
Br.Portuguese	SVO/Pr/NG/NA	9	F/F	Agr	+	+	-	-	-	+	+	+	-	-	+	-	+	-	+	PGN/TAV	Abs:S
Hindi	SOV/Po/GN/AN	23	F/F	+	-	-	-	-	+	+	+	-	-	-	-	-	-	-	+	NG/Fut	Erg:A
Hungarian	SOV/Po/GN/AN	23	F/F	+	-	-	-	+	+	+	-	-	-	-	-	-	+	-	+	NP/TM	Abs:S
Japanese	SOV/Po/GN/AN	23	M/R	+	-	-	-	-	-	-	-	+	-	-	-	+	-	-	+	T	(Hon)
Korean	SOV/Po/GN/AN	23	F/F	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-/TAM	Abs:S
Turkish	SOV/Po/GN/AN	23	F/F	+	-	-	+	-	-	-	-	-	-	-	-	-	ind	-	+	PN/TVM	Abs:S

Explanation. "WO type" stands for the language's word order type, as per Greenberg/Hawkins, with "G/H" the relevant index in Greenberg's Appendix II. The "Var" column indicates variation, for matrix clause/dependent clauses; "F" stands for free, "M" for mixed, and "R" for rigid. The next three columns provide information on how subjects and objects are distinguished: by "Case" (possibly just by Accusative marking on the object), positioning ("Pos"), or by Tune. The columns thereafter regard modifiers in general, and the morphological strategies available in a language for realizing them (Croft, 1990): "Case" case marking, "Comp" compounding, "Jux" juxtaposition, "Agr" agreement, "Sup" suppletion, "Adp" adposition, "Lnk" linker, "L+Ad" linker+adposition, "S+Ad" suppletion+adposition, and "Afx" affixation. The next three columns specify whether the language has "Art" articles (or just one, or none), "Expl" expletives, and whether it allows for "Drop" dropping (usually of the subject). The final two columns specify verbal morphology. "Verb." gives more information on verbal form: whether there is any indication of "P" person, "N" number, or "G" gender, and "T" tense (possibly only "Pst" past, "Pres" present, or "Fut" future), "A" aspect, "V" voice, or "M" modality. If a "T", "M", "V" or "A" is absent it is realized using an auxiliary. The last column indicates whether the verb agrees with any of its complements, and if so, with what: "Abs:S" absolutive subject, "Erg:A" ergative Actor.

with OV ordering (at some clause level) has rigid, mixed, or free word order.

(356) VARIATION HYPOTHESES FOR OV WORD ORDER

a. VARIATION HYPOTHESIS OV-1:
$\mathsf{OV} \;\&\; \mathsf{Strat(SubjObj,Case)} \;\&\; ((\mathsf{Agr(ErgActor,Verb)} \;\&\; \mathsf{Drop}) \vee (\mathsf{Agr(AbsSubj,Verb)} \;\&\; (\mathsf{VerbForm}(\mathsf{Tense} \;\&\; (\mathsf{Aspect} \vee \mathsf{Mood} \vee \mathsf{Voice}))))) \Supset \mathsf{free}$

b. VARIATION HYPOTHESIS OV-2:
$\mathsf{OV} \;\&\; \mathsf{Strat(SubjObj,Case)} \;\&\; (\neg\mathsf{Agr(Subj,Verb)} \vee \neg\mathsf{Drop}) \Supset \mathsf{mixed}$

c. VARIATION HYPOTHESIS OV-3:
$\mathsf{OV} \;\&\; \neg\mathsf{Strat(SubjObj,Case)} \;\&\; \neg\mathsf{Drop} \;\&\; \neg\mathsf{Agr(Subj,Verb)} \Supset \mathsf{rigid}$

Looking at the data, we see that Hindi, Hungarian, Korean and Turkish all have a fairly rich verbal and nominal morphology. From Skalička's typology it then follows that these languages have a relatively free word order, which they indeed do. On the other hand, Japanese does have a nominal case system, but verbs only inflect for tense and have no agreement with the subject.[13] We understand that its mixed word order arises from this combination of the presence of a nominal case system and the lack of a rich verbal morphology. This is confirmed by German dependent clause word order, which is mixed (as long as there is no morphological ambiguity; otherwise it rigidifies).

Finally, the hypotheses also explain the rigid ordering in Dutch dependent clauses. The presence of case marking is significant to the explanation of why Dutch differs from German with respect to dependent clause word order. If it were not, we could possibly obtain a mixed word order by using prepositions to realize Case. However, as the examples in (357) illustrate, we cannot.

(357) a. **Dutch**

... de man wiens foto Kathy aan Elijah gaf.
... the man whose photo Kathy to Elijah gave.

"The man whose photo Kathy gave to Elijah."

b. * de man wiens foto aan Elijah Marie gaf.

(358) FURTHER HYPOTHESES ON THE BASIS OF OV DATA

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[13] Unless one considers honorification as a kind of agreement.

a. Articles:
$\mathsf{OV}\ \&\ \mathsf{free} \Supset \neg(\mathsf{Art(def)} \wedge \mathsf{Art(indef)})$, or
$\mathsf{OV}\ \&\ (\mathsf{Art(def)}\ \&\ \mathsf{Art(indef)}) \Supset \neg\mathsf{free}$

b. Use of case:
$\mathsf{Strat(NounModif,Case)} \Supset \mathsf{Strat(SubjObj,Case)}$

c. Expletives:
$\mathsf{Agr(AbsSubj,Verb)}\ \&\ (\mathsf{VerbForm(Tense}\ \&\ (\mathsf{Aspect} \vee \mathsf{Mood} \vee \mathsf{Voice})))$
$\Supset \neg\mathsf{Expl}$

d. Pro-drop:
$\mathsf{Agr(AbsSubj,Verb)}\ \&\ (\mathsf{VerbForm(Tense}\ \&\ (\mathsf{Aspect} \vee \mathsf{Mood} \vee \mathsf{Voice})))$
$\Supset \mathsf{Drop}$

It is hardly surprising that for SVO word order we can give hypotheses that are similar to (356). Using the data for Czech, Dutch, English, French, German, Hebrew, Italian, Mandarin, Brazilian Portuguese, and Swedish, we formulate the variation hypotheses in (359).

(359) variation hypotheses for SVO word order

a. variation hypothesis SVO-1:
$\mathsf{SVO}\ \&\ \mathsf{Strat(SubjObj,Case)}\ \&\ (\mathsf{VerbForm(Tense}\ \&\ (\mathsf{Aspect} \vee \mathsf{Mood})))$
$\Supset \mathsf{free}$

b. variation hypothesis SVO-1':
$\mathsf{VerbForm(Tense}\ \&\ \mathsf{Aspect}\ \&\ \mathsf{Voice}\ \&\ \mathsf{Mood)} \Supset \mathsf{free}$

c. variation hypothesis SVO-2:
$\mathsf{SVO}\ \&\ \mathsf{Strat(SubjObj,Case)}\ \&$
$(\mathsf{VerbForm(Tense}\ \&\ \neg(\mathsf{Aspect} \vee \mathsf{Mood}))) \Supset \mathsf{mixed}$

d. variation hypothesis SVO-3:
$\mathsf{SVO}\ \&\ \neg\mathsf{Strat(SubjObj,Case)}\ \&\ (\mathsf{VerbForm(Tense}\ \&\ \neg\mathsf{Mood})) \Supset$
rigid

Again, there is an interesting interaction between nominal and verbal morphology. If a language has both a rich verbal and a rich nominal morphology, then it has free word order – confirming Skalička's predictions. Straight examples of such languages in the data are Czech, Greek, and Russian, with Brazilian Portuguese presenting an interesting exception. Although native informants judge word order in Brazilian Portuguese as free (in the sense used here), it only shares with the other free SVO languages that it has a rich verbal morphology. There is no rich nominal morphology, and the subject and object are indicated using either agreement, positioning, or tune, rather than case. The variation hypothesis SVO-1' captures the idea that if we have a very rich verbal morphology in an SVO language, then this suffices to conclude the language has free word order.

Mixed word order in SVO languages seems to be primarily determined by the presence of a rich nominal morphology, as in the case of German. Verbal morphology appears to be less important here. French has a richer verbal morphology than German, but lacks a nominal case system and – accordingly– has a rigid rather than a mixed word order. Observe that this provides an interesting similarity to the OV-case. The data shows that mixed word order is possible with a rich nominal morphology, even though the verb may only show tense – cf. Japanese.

In general, rigid SVO word order appears to ensue as soon as there is no rich nominal morphology nor a rich verbal morphology. There is at least one notable exception - Dutch. Dutch does not have a case system[14] nor a rich verbal morphology, and yet it does have a mixed word order like German (and contrary to English). The data presented in the table in Figure 6.1 shows us only that, if we restrict ourselves to Type X languages, then what distinguishes Dutch (mixed) from English (rigid) is the absence of the *Linker+Adposition* strategy. This strategy for realizing nonpronominal possessor genitival constructions is secondary in English (Croft, 1990)(p.34ff). However, it may indicate a positional fixation of what languages with a nominal case system would simply use morphology for. This view seems to be supported by the typological characterization of English. English is *both* Type X and Type XI, due to its positional fixation of the different basic strategies for realizing genitives (Linker: GN, Adposition: NG). Hence, I propose to reformulate variation hypothesis SVO-2 (359c) into (360) below, to cover (at least) Dutch mixed word order. The hypothesis explains the mixed word order of Dutch on the basis of Dutch being less positional than English (and thus more like German, even though Dutch has no "overt" nominal case system).

(360) REVISED VARIATION HYPOTHESIS SVO-2:

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[14] Dutch does not have a nominal case system *anymore* – there are still various remnants of cases though.

$$\mathrm{SVO}\ \&\ (\mathrm{Strat(SubjObj,Case)} \vee (\mathrm{NG}\ \&\ \neg\mathrm{Strat(NomMod,L{+}Ad)})\ \&\ (\mathrm{VerbForm(Tense}\ \&\ \neg(\mathrm{Aspect} \vee \mathrm{Mood})))) \Supset \mathrm{mixed}$$

(361) FURTHER HYPOTHESES ON THE BASIS OF SVO DATA

a. ARTICLES:
$\mathrm{SVO}\ \&\ \mathrm{free} \Supset \neg(\mathrm{Art(def)} \wedge \mathrm{Art(indef)})$, or
$\mathrm{SVO}\ \&\ (\mathrm{Art(def)}\ \&\ \mathrm{Art(indef)}) \Supset \neg\mathrm{free}$,
$\mathrm{SVO}\ \&\ (\mathrm{rigid} \vee \mathrm{mixed}) \Supset (\mathrm{Art(def)}\ \&\ \mathrm{Art(indef)})$

b. USE OF CASE:
$\mathrm{Strat(NounModif,Case)} \Supset \mathrm{Strat(SubjObj,Case)}$

c. PRO-DROP:
$\mathrm{free} \Supset \mathrm{Drop}$, $\mathrm{rigid} \vee \mathrm{mixed} \Supset \neg\mathrm{Drop}$

Finally, for OV I lack sufficient data to come to a proper characterization. To cover the data in Figure 6.1, I propose the hypotheses in (362).

(362) VARIATION HYPOTHESES FOR VO WORD ORDER

a. VARIATION HYPOTHESIS VO-1:
$\mathrm{VO}\ \&\ \mathrm{Strat(SubjObj,Case)}\ \&\ \mathrm{VerbForm(Aspect}\ \&\ \mathrm{Mood)} \Supset \mathrm{free}$

b. VARIATION HYPOTHESIS VO-2:
$\mathrm{VO}\ \&\ \neg\mathrm{Strat(SubjObj,Case)}\ \&\ \mathrm{VerbForm(Tense}\ \&\ \neg(\mathrm{Aspect}\ \&\mathrm{Mood})) \Supset \mathrm{rigid}$

To recapitulate, I presented Steele's characterization of (in)variability in word order as either rigid, mixed, or free. Based on empirical data from typologically different languages, I formulated several hypotheses that *predict* when a language has rigid, mixed, or free word order (thus improving on (Steele, 1978)). The empirical findings underlying the hypotheses confirmed to an important degree the predictions made by Skalička's (morphological) typology of languages (Skalička and Sgall, 1994; Sgall, 1995b), in showing the interrelation between morphology and variability. The proposal advanced here distinguishes itself from Skalička in discerning mixed word order besides rigid and free word order, and covering its predictability. This finer distinction is not vacuous. Mixed word order languages may realize information structure differently than either rigid or free languages. Unlike rigid languages, mixed languages can use word order to realize information structure, but not to the degree that free languages can. One consequence is that mixed languages have a more complex interaction between tune and word order than either rigid or free languages. On the other hand, whereas free word order languages usually lack articles, mixed do have them and are thus able to indicate contextual boundness that way.

6.4 THE CATEGORY OF INFORMATIVITY

As I already noted in the introduction to this chapter, we know from various contrastive studies that languages may realize information structure in different ways. For many different frameworks it has also been argued how they are able to represent information structure, taking into account such cross-linguistic variation. The aim in this section is to advance several hypotheses that *predict* when a language of a given type avails itself of particular structural indications of informativity, elaborating on (Sgall et al., 1986). I restrict myself to the use of just word order and tune, the relation between which I assume to be one of relative opposition: If a language does not use word order, it uses tune.

Below I start in §6.4.1 with a null hypothesis derived from (Sgall et al., 1986), working towards a set of hypotheses that predict what a language's 'prefered' or *canonical focus position* is. By a language's canonical focus position (or CFP for short) I understand the position in a sentence where we would expect the information structure's focus (focus proper) to be realized, given an unmarked, canonical word order or an unmarked intonation pattern. Various authors have associated the CFP with sentence-finality, for SVO languages like Czech or English (Sgall et al., 1986; Vallduví and Engdahl, 1996) but also for SOV languages like Sinhala or Tamil (Herring and Paolillo, 1995). Here, I examine data from VX, XV and SVO languages, and present in §6.4.2 a set of hypotheses that effectuates sentence-finality but does not by definition imply it.

Naturally, a focus needs not always be realized in the canonical focus position. There may be various reasons for doing so. The thematic structure of a text and its overall organization may for example play a role, and an obvious factor is the information structure to be realized. For example, consider (363). Without any further indications, people understand "Christopher read a book yesterday" to mean that *yesterday* is the focus proper, and the focus may extend to any point leftwards.[15] The other sentences realize different information structures. In (363b-d) the words after the pitch accent realize (part of) the topic.

(363) **English**
Christopher read a book yesterday.
a. Christopher read a book YESTERDAY.
b. Christopher read A BOOK yesterday.
c. Christopher READ a book yesterday.
d. CHRISTOPHER read a book yesterday.

Thus, two questions arise here: How does a focus project, and when does a language use what means to realize an information structure focus in a position different from the CFP? I address focus projection in §6.4.3, primarily on the basis of the data presented in (Vallduví and Engdahl, 1996). Subsequently, I present in §6.4.4 a set of hypotheses that predict when languages use word order, tune or a combination thereof to realize foci in other than the canonical focus position.

6.4.1 THE NULL HYPOTHESIS

To start, we can propose an initial version of a very general hypothesis about how the build-up of a sentence may reflect its information structure as represented in the underlying linguistic meaning, (364).

(364) INFORMATIVITY HYPOTHESIS I (INITIAL VERSION)
In the unmarked case (unmarked mixed, free word order or unmarked tune), languages tend to realize (verbal) contextually bound dependents/heads before contextually nonbound ones, and contextually nonbound dependents in canonical/systemic ordering.

The formulation of INFHYP1 is nothing new. In different guises it appears throughout work in the Prague School of Linguistics, notably in FGD's topic-focus articulation (Sgall et al., 1986; Hajičová et al., 1995; Hajičová, 1993) and its use of Firbas's communicative dynamism (Firbas, 1992).

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[15] With an unmarked tune, or just an `H*` pitch accent on "yesterday", (363) can be an answer to "What happened?".

Despite its simplicity, InfHyp1 holds across a surprisingly large range of language types. For example, it holds for most of the OV languages we have considered so far. In rigidly verb-final languages like Japanese or Tamil, the focus proper occupies the immediately preverbal position. In non-rigid verb-final languages like Sinhala the focus proper can also be the postverbal dependent (Herring and Paolillo, 1995). And, InfHyp1 holds also for German, which has a mixed OV word order at the subordinate clause level, where the preverbal position (right before the verbal cluster) is usually considered to be the prefered position for the informational focus.

(365) **Japanese**

Taroo-wa	[susi-o]$_F$	tabeta.
Taro-TOPIC	susi-ACC	eat-PAST

"Taroo ate the SUSHI."

(366) **Tamil**

anta	nātt-il	[oru	aracaṉ]$_F$	iru-nt-āṉ
that	country-LOC	one	king	be-PAST

"In that country, there was A KING." (Herring and Paolillo, 1995)(p.182)

(367) **Sinhala**

oya	kaelaeae-we	hiṭiyaa	[nariy-ek]$_F$.
that	forest-LOC	live-PAST	jackal-INDEF

"In that forest lived A JACKAL." (Herring and Paolillo, 1995)(p.170)

Similarly, we find that the SVO languages we have considered all tend to prefer to place the focus at the end of the clause (in the unmarked case). This holds particularly for the SVO languages with mixed word order, like Dutch or German, or free word order, like Czech, Greek or Russian.

However, the initial version of InfHyp1 is not obeyed by free OV languages (notably, type XXIII). For example, Hindi, Hungarian and Turkish appear to form a counter-example to the initial formulation of InfHyp1 (Hoffman, 1995a), (Vallduví and Engdahl, 1996), (Vasishth,p.c.). These languages prefer to place the informational focus directly before the verb -

wherever the verb is placed. In other words, sentence-finality is not a criterion for the placement of focus (proper). Consider for example (368), cited in (Vallduví and Engdahl, 1996), and (369), from Hoffman (1995a)(p.106).

(368) **Hungarian**

Mari JÁNOST látta.
Mary John-Acc see-Past

"Mary saw JOHN"

(369) **Turkish**

a. Esra kitab-ı okuyor
Esra book-Acc read-PresProg
"Esra is reading the BOOK."

b. Kitab-ı Esra okuyor
book-Acc Esra read-PresProg
"As for the book, it is Esra who is reading it."

Only if we leave the verb in final position, like in (368) or (369), InfHyp1 is obeyed. Changing the word order of (368) to (370) means that InfHyp1 no longer applies, even though the word order as such is unmarked.

(370) **Hungarian**

Mari látta Jánost.
Mary see-Past John-Acc

"MARY saw John"

6.4.2 PREDICTING A LANGUAGE'S CANONICAL FOCUS POSITION

Thus, leaving marked word order constructions like "subjective ordering" (Sgall et al., 1986) or focal fronting aside, InfHyp1 appears to cover (most) non-canonical orders in mixed OV and mixed or free SVO languages, but seems to fail on free OV languages. Can we find a certain system in these observations? The proposal I advance here involves four aspects:

1. the dominant word order (XV/VX/SVO), as per the Greenberg/Hawkins typology;
2. the degree of variability (rigid/mixed/free), as implied by the hypotheses presented earlier in this chapter;

3. the presence or absence of a productive prosodic system (tune) and its interaction with the degree of variability; and,
4. Venneman's idea of category consistency (cf. (Venneman, 1977; Hawkins, 1983)).

To start with the last, Venneman's idea of category consistency is embodied in his "Natural Serialization Principle". This principle states that languages linearize all their operator-operand pairs *consistently*, thus either (strictly) operator before operand, or operand after operator. Hawkins (1983) convincingly argues that Venneman's principle *as such* cannot be used as an adequate explanation of word order typology. But the idea that there is a certain consistency in linearization is perhaps not entirely without merit. Namely, it does seem that languages tend to have a canonical focus position relative to the verbal head that is consistent with its dominant word order. This leads to (371).

(371) a. OV ⋑ immediate preverbal position
b. VO ⋑ postverbal position

Subsequently, let us bring tune into the picture. Languages use tune and word order (among other means) to *relative* degrees. This is a perspective already advanced by Sgall *et al.* in (1986) and later work. As said earlier, we consider the following -initial- relation between variability in word order and tune.

(372) (OV ∨ VO ∨ SVO) & rigid ⋑ tune

In other words, if a language has rigid word order, it is predicted to rely predominantly on tune, (at least for the unmarked case(s) realizing information structure).

Next, SVO behaves like OV as soon as verb secondness is involved, since verb secondness often leads to the formation of a clause-final verbal cluster. Similarly, the following holds: if we have SVO but no verb secondness, then SVO behaves like VO. From these observations and (371a) we predict that the default focus position can be found towards the end of the sentence in rigid, mixed and free SVO.

(373) a. ((rigid ∨ mixed ∨ free) & SVO & (V2 ⊃ VFinal) ⋑OV)
⋑ immediate preverbal position

b. $((\mathsf{rigid} \vee \mathsf{mixed} \vee \mathsf{free}) \mathbin{\&} \mathsf{SVO} \mathbin{\&} \neg(\mathsf{V2} \supset \mathsf{VFinal}) \Supset \mathsf{VO})$
$\Supset$ $\mathsf{postverbal\ position}$

Based on the above observations (and the implications relating them), we arrive at the following formulation of our first (proper) hypothesis regarding the realization of information structure. The hypothesis reformulates (364), and determines where we should expect the canonical focus position in a particular language, given its type.

(374) INFORMATION STRUCTURE HYPOTHESIS 1 (CANONICAL FOCUS POSITION):
The canonical focus position (CFP) is determined by either of the following hierarchies, depending on the language's type:

a. **OV/SVO-UFP-hierarchy**:
$\mathsf{immediate\ preverbal\ position} \ \Subset$
$(\mathsf{rigid} \vee \mathsf{mixed} \vee \mathsf{free}) \mathbin{\&} \mathsf{SVO} \mathbin{\&} (\mathsf{V2} \supset \mathsf{VFinal})$
$\vee$
$(\mathsf{rigid} \vee \mathsf{mixed} \vee \mathsf{free}) \mathbin{\&} \neg\ \mathsf{tune} \mathbin{\&} \mathsf{OV}$

b. **VO/SVO-UFP-hierarchy**:
$\mathsf{postverbal\ position} \ \Subset$
$(\mathsf{rigid} \vee \mathsf{mixed} \vee \mathsf{free}) \mathbin{\&} \mathsf{SVO} \mathbin{\&} \neg(\mathsf{V2} \supset \mathsf{VFinal})$
$\vee$
$(\mathsf{rigid} \vee \mathsf{mixed} \vee \mathsf{free}) \mathbin{\&} \neg\ \mathsf{tune} \mathbin{\&} \mathsf{VO}$

Remark 19 (Pre-/post-verbal positioning $\not\Rightarrow$ sentence-finality). There are a few remarks that we should make about INFHYP1, (374). First of all, although actual constructions may give the impression that a preverbal or postverbal position *coincides* with sentence-finality, we do not imply this. The hypothesis is deliberately stated in terms of (immediate) pre- and postverbal positioning, on the basis of the consistency noted in (371). Sentence-finality is effectuated, in other words, but it is not defining. And exactly because we perceive of it that way, we can relate in a coherent way the *superficially* different CFPs of for example SVO languages like Dutch and German (behaving closely like OV in more complex matrix clause constructions) and OV languages like Hungarian or Turkish.

Secondly, the data about VO languages and their information structure is too scarce to make any genuine predictions about their structure. We return to this point again below. $\circledast$

6.4.3 FOCUS PROJECTION

By focus projection we understand the phenomenon where more wordgroups are interpreted as realizing part of the focus than just the wordgroup realizing the focus proper. For example, take the English sentences in (375) below.

(375) **English**

a. Elijah left his cowboy-boots [on the TABLE $]_F$.

b. Elijah left [his cowboy-boots [on the TABLE $]_F$ $]_F$.

c. Elijah [left [his cowboy-boots [on the TABLE $]_F$ $]_F$ $]_F$.

Here, "on the table" realizes the focus proper. In (375a) the boundary between the focus and the topic is directly before the focus proper. In (375b,c) we "project" that boundary further leftwards, understanding more wordgroups as realizing parts of the focus. The same holds for example for Dutch and German, both at the matrix clause level (SVO) and the subordinate clause level (SOV) as the examples below (for Dutch) illustrate.

(376) **Dutch**

a. Elijah heeft zijn cowboy-laarzen [op de TAFEL $]_F$ laten staan.

b. Elijah heeft [zijn cowboy-laarzen [op de TAFEL $]_F$ $]_F$ laten staan.

(377) a. ...omdat Elijah [zijn COWBOY-LAARZEN $]_F$ op de tafel heeft laten staan.

b. ...omdat [Elijah [zijn COWBOY-LAARZEN $]_F$ $]_F$ op de tafel heeft laten staan.

All the examples above realize different information structures. They illustrate the point indicated earlier, namely that focus projection or the possibility thereof may be important factor in how to realize information structure unambiguously.

Interestingly, languages may project foci into different directions. For example, Hungarian allows for *rightwards focus projection if* the verbal dependents are all ordered *canonically* (i.e. according systemic ordering). The sentences in (378) exemplify this (Komlósy, cited by Vallduví & Engdahl). Vallduví & Engdahl indicate that focus projection in Hungarian can also be *leftwards.*

(378) **Hungarian**

a. Mari [[[almát]$_F$ eszik]$_F$ a kertben]$_F$.
Mary apple-ACC eat the garden-IN
"Mary eats apples in the garden."

b. Mari [[[beteg]$_F$ volt]$_F$ a tegnap]$_F$.
Mary sick be-PAST yesterday
"Mary was sick yesterday."

The tendency to project a focus rightwards stands in an interesting contrast to focus projection in most other OV and SVO languages (which tend to behave OV-like in the Mittel- and Nachfeld - cf. Dutch, German). Most OV and SVO languages appear to project strictly towards the *left* from the focus and the nuclear stress it carries. On the other hand, the requirements for focus projection in Hungarian are purely word order-related, relying as they do on the presence (or absence) of a canonical order.

That tune does not play a significant role in the realization of information structure in Hungarian at all also seems to be indicated by the following contrast between Turkish and Hindi on the one hand, and Hungarian on the other. As Vallduví & Engdahl report, the focus must be preverbal in Hungarian (unless the verbal head is the focus proper, in which case it is placed clause-initial). If the focus is formed by a dependent whose canonical position is not immediately preverbal, then it has to be "moved" there. Because of the minimal role that tune seems to play, we cannot leave the dependent in situ and *stress* it - as the minimal pair in (379) briefly illustrate, (Vallduví and Engdahl, 1996).

(379) **Hungarian**

a. * Attila félt [a FÖLDRENGÉSTŐL]$_F$.
Attila fear-PAST the earthquake
"Attila feared the EARTHQUAKE."

b. Attila [a FÖLDRENGÉSTŐL]$_F$ félt.

Turkish and Hindi differ from Hungarian in this respect. There, we can leave a dependent in situ and use a marked tune to realize it as (part of) the focus. The examples in (380) form a minimal pair illustrating the Turkish situation.

(380) **Turkish**

a. Bir hizmełçi masa-nın üzer-i-ne not-u
a servant table-GEN top-POSS-DAT note-ACC
[YEMEK-ten önce $]_F$ bırak-tı.
meal-ABL before leave-PAST
"A servant put the note on the table before lunch."

b. Bir hizmełçi [YEMEK-ten önce $]_F$ masa-nın üzer-i-ne not-u bırak-tı.

We would like to propose the following observations. First of all, there is the main point that the possibility of focus projection influences how a sentence may be interpreted as realizing a particular information structure. We thus regard it as an important factor in determining the choice of structural indications of informativity.

Secondly, a focus can be projected over wordgroups (dependents) that are ordered according to systemic ordering. This also follows from (Sgall et al., 1986)(p.194ff), where NB elements by definition have to appear in systemic ordering. Here, we observed this phenomenon for Hungarian (Vallduví and Engdahl, 1996), and we can also illustrate on the English examples in (381).

(381) **English**

a. Christopher gave a book [to KATHY $]_F$.

b. Christopher gave Kathy [a BOOK $]_F$.

Arguably, the focus in (381a) can be projected further leftwards, but not in (381b) because of the dative-shifted **Beneficiary**. Other examples can be found in (Sgall et al., 1986)(p.194ff).

Thirdly, focus projection can in principle be either leftwards or rightwards. Given the Hungarian data, and the contrasting data from Hindi and Turkish, the direction in which a focus may project over verbs and systemically ordered wordgroups seems at least to depend on the productivity of tune in the given language.

6.4.4 CHANGING FOCUS

In this section we have a look at constructions that realize information structure where the focus proper appears in a position other than the canonical focus position. Like we said earlier, there may be various reasons for doing so, arising from the information structure and possible focus projections, thematic structure, etc. Bearing (371) in mind, having the focus proper in a non-canonical position can mean two things. Either the focus element appears in a position other than the CFP but that position is still consistent with (371), or it is in a position that is neither the CFP nor consistent with (371).

For example, in an OV language the focus could be preverbal but not *immediately* preverbal, in which case consistency would be maintained. However, if the focus would not be immediately preverbal *nor* preverbal at all, then both InfHyp1 (describing the unmarked or canonical case) and consistency would be violated. Naturally, other factors in a language system determine whether we can obtain these different marked cases at all - for example, in a rigidly verb-final OV language it is hardly likely that a postverbal focal element would be found.

From a viewpoint of economy, like Sgall *et al.* discuss in (1986) for dependency grammar in general, we could set up the following Informativity Markedness Principle. We use CC for category consistency, and FP for focus position.

(382) Informativity Markedness Principle:
{ CC & UFP }
$\leq_{IM}$ { CC & non-canonical FP }
$\leq_{IM}$ { non-CC & non-canonical FP}

In words, the least marked construction is one in which the focus proper is realized in the canonical focus position. A more marked construction is one where the focus proper is realized in a non-canonical focus position, but still consistent with the general operator-operand direction. More marked than either of the previous constructions is one where the focus proper is not realized in canonical focus position, nor category consistency is obeyed.

Intuitively, if we would follow out economy, then we would also get the prediction that a language would first tend to the use its predominant strategy for realizing information structure, to obtain a more marked focus position CC & non-canonical FP, (unless the construction would be ambiguous between a focus proper realized in CFP and a marked FP). To obtain a really marked focus position non-CC & non-canonical FP the language would resort to a different strategy, possibly in combination with its predominant strategy. Note that there may be different strategies for mixed and free word order languages. For example, mixed languages have articles at their disposal to realize contextual boundness, whereas free (in general) do not.

For example, take again OV languages. An OV language like Sinhala has mixed word order, and is non-rigid in its verb-finality. InfHyp1 predicts that the unmarked focus position is immediately preverbal. Subsequently, we predict that more marked focus positions would either be obtainable using word order, placing it towards the beginning of the sentence (consistently preverbal), or using tune (and word order) to place the focus *after* the verb. As it turns out, this is indeed the case - cf. Herring & Paolillo (1995).

Similar observations, consistent with the above proposal, can be made for Japanese. Although Japanese is rigidly verb-final and has an immediately preverbal unmarked focus position (383a), we can obtain a more marked focus by ordering it at the beginning of the sentence (383b) without having to use any marked tune. [16]

(383) "What did Taro eat?"

a. **Japanese**

Taroo-ga	susi-o	tabeta.
Taro-NOM	sushi-ACC	eat-PAST

"Taro ate SUSHI."

b. Susi-o Taroo-ga tabeta.

The proposal also holds for free OV languages like Turkish or Hindi, cf. (Vallduví and Engdahl, 1996) for Turkish.[17] Furthermore, we can observe this behavior in mixed SVO languages (V2-case) like Dutch and German , and for a free SVO language like Czech we already illustrated this.

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[16] Having said that, native speakers may prefer to put some stress on the marked focus, even when a *-wa* particle is used to indicate explicitly the topic. Note that the $-ga$ particle does not need to indicate focus, cf. (Heycock, 1993).

[17] At the same time, the data is slightly inconclusive about Hungarian. Obviously, because Hungarian does not have a particularly productive tune, we would not predict to observe a post-verbal marked focus. Moreover, the constraint that the focus position has to be immediately preverbal would seem to contradict the possibility to obtain a (preverbal) marked focus using word order only, in Hungarian. In the light of the scarcety of the data available to us, we leave Hungarian out of the equation for the moment. It may mean that we will have to make a more fine-grained prediction on a future occasion, but that does not invalidate the approach as such.

On the basis of these observations, we formulate the following hypothesis, InfHyp2. InfHyp2 concerns realizations of information structure that are more marked due to their realization of the focus proper in other than the canonical focus position. We use "ambiguous" to indicate whether a construction (sentence) would be 'ambiguous' between a canonical and a non-canonical focus position without any further structural indication like tune.

(384) Information Structure Hypothesis 2 (marked realization)

a. $(\mathsf{CC}\ \&\ \neg\mathsf{UFP}\ \&\ \neg\mathsf{ambigous})$
$\Supset ((\mathsf{mixed} \vee \mathsf{free}) \Supset \mathsf{word\ order})\ \&\ (\mathsf{rigid} \Supset \mathsf{tune})$

b. $(\neg\mathsf{CC}\ \&\ \neg\mathsf{UFP}\ \&\ (\mathsf{ambiguous} \vee \neg\mathsf{ambigous}))$
$\Supset ((\mathsf{rigid} \vee \mathsf{mixed} \vee \mathsf{free}) \Supset \mathsf{word\ order}\ \&\ \mathsf{tune})$

Remark 20 (Marked realization has to be grammatical). Quite naturally, the implications of InfHyp2 all are, ultimately, constrained by what is well-formed in a particular language. If a language does not have a very productive word order system, InfHyp2 should not be interpreted to state that there is one nevertheless. But, within these limits, InfHyp2 seems to cover even the rare constructions like Y-movement in English. ⊛

To recapitulate, we have InfHyp1 which predicts that the unmarked focus position is consistent with the directionality of the dominant word order (OV/VO, with SVO split into different cases). Furthermore, InfHyp2 predicts that more marked focus positions can be obtained using either word order or both word order and tune, depending on how marked (with respect to the *Informativity Markedness Principle*) the construction would be and whether it by formal structure alone it would be ambiguous between a canonical and a non-canonical focus position.

Specifically, for VO languages, the hypotheses predict the following structural indications of informativity in OV languages.

(385) **Structural indications of informativity in OV**:

a. Rigidly and non-rigidly verb-first OV languages have an immediately post-verbal unmarked focus position.

b. Rigid VO realize information structure using predominantly tune; mixed and free VO languages use predominantly word order.

c. Non-rigidly verb-initial OV languages can have a marked immediately preverbal focus.

d. Rigidly and non-rigidly verb-initial OV languages with mixed or free word order can have marked focus position towards the end of the sentence, using just word order unless the structure as such would be ambiguous between a CFP construction.

Because data about structural indications of informativity in languages with VO word order is very scarce, it is hard to verify the above predictions. Kroeger (1993) briefly discusses the realization of information structure in Tagalog, and an informal inspection of Biblical Hebrew only reveals a partial picture of what appears to be a rather complex situation. Inspecting word order variation in Biblical Hebrew in context (i.e. in the bible) appears to indicate that it has a rather mixed word order, and that it places pronominal clitics directly after the verb (Zussman, p.c.). It uses word order as its primary structural indications of informativity, in other words. With regard to the unmarked focus position, Biblical Hebrew indeed seems to prefer the immediately postverbal position. Furthermore, it allows for an SVO variation, in which the preverbal dependent in fact realizes a (marked) focus. Whether there is any particular tune associated to this fronting is not clear, and requires further research.

The situation in Tagalog is more complex, due to its rich voice system, and the influence of a dependent's definiteness on whether it can actually be realized in nominative case. In the examples below, all from (Kroeger, 1993)p.62ff, the gloss AV means active voice, OV objective voice, and IV "indirect objective" voice.

(386) **Tagalog**

Ano	ang	kinain	mo?
What	Nom	Perf.OV-eat	2.Sg.Gen

"What did you eat?"

(387) a.

Kinain	ko	[ang-isda]$_F$
Perf.OV-eat	1.Sg.Gen	Nom-fish

"I ate the fish"

b.

Kumain	ako	[ng-isda]$_F$
Perf.AV-eat	1.Sg.Nom	Gen-fish

"I ate (some) fish."

The question in (386) is formulated in objective voice (ov). In (387a) we have the same voice, with a **Patient** that is in nominative case and (necessarily) definite. (387b) uses active voice, making it impossible for the object to be in nominative case and to be definite.

(388) **Tagalog**

Ano	ba	ang	binili	mo	sa-pamilihan?
What	Ques	Nom	Perf.OV-buy	2.Sg.Gen	Dat-market

"What did you buy at the market?"

(389) a.

Binili	ko	[ito-ng damit]$_F$.	
Perf.OV-buy	1.Sg.Gen	Nom-this-Link	dress

"I bought this dress."

b. [Ito-ng]$_F$ damit ang binili ko.

Now, let us consider a question with the verb in active voice (rather than objective voice, as above).

(390) **Tagalog**

Sino	ang	gumawa	ng-sapatos	na	iyon?
who	Nom	AV.Perf-make	Gen-shoe	Link	that

"Who made those shoes?"

(391) a.

?Ginawa	[ni-Bing]$_F$
OV.Perf-make	Gen-Bing

"Bing made (them)."

b.

[Si-Bing]$_F$	ang	gumawa	ng-sapatos	na	iyon.
Nom-Bing	Nom	AV.Perf-make	Gen-shoe	Link	that

"Bing is the one who made those shoes."

The answer in (391b) is the preferred answer here, cf. (Kroeger, 1993)(p.63). Thus, we see that Tagalog can -in principle- place its focus either preverbally and postverbally. Thereby we might understand the postverbal position to be the unmarked one, based on the observation that topicalization using the *ay*-inversion construction places an element in the preverbal position, cf. (Kroeger, 1993)(p.67)

SUMMARY

Based on empirical data, we presented a typological characterisation of variability in word order, and a set of hypotheses that predict when (and why) languages make use of strategies like word order or tune to realize information structure. The first hypothesis, INFHYP1, predicts that the canonical focus position is the immediately preverbal position in OV languages, and in SVO constructions that have a clause-final verbal cluster. For VO languages and SVO constructions without verb-secondness, INFHYP1 predicts that the canonical focus position is post-verbal. We observed that sentence-finality may be effectuated, but that it is not defining. This enables us to relate the canonical focus position of (complex) Dutch and German clauses to the realization of information structure in OV languages like Hungarian or Turkish.

The second hypothesis, INFHYP2, predicts how more marked realizations are realized. We noted that thematic structure and the possibility of focus projection may determine how information structure is to be realized, and that only through more marked constructions such realization can sometimes be achieved (e.g. to avoid ambiguity). For example, INFHYP2 makes the following predictions about realizing the focus proper in a non-canonical focus position. As long as the construction cannot be understood to realize a focus in the canonical focus position and the non-canonical focus position is placed relative to the canonical focus position category consistently, then word order can be used. Otherwise, an interaction between tune and word order is predicted.

With respect to the hypotheses, we noted that there is a difference in the use of these strategies among languages with rigid, mixed and free word order, and that strategies are used to a relative rather than an absolute degree.

The discussion in this chapter confirmed various of the principal hypotheses advanced in the Prague School of Linguistics, and most recently in FGD, about language typology (Skalička and Sgall, 1994; Sgall, 1995b) and the realization of information structure (Sgall et al., 1986; Hajičová, 1993). Even though we looked at a relatively small number of languages, the hypotheses have been formulated against data that is typologically more diverse than is usually considered in the literature.

In subsequent chapters we look in more detail at how we can formalize the idea that information structure is a fundamental parameter in determining the realization of a sentence. Chapter 7 presents detailed architectures modelling rigid, mixed and free word order and the use of word order to realize information structure. Chapter 8 extends the formal models to cover tune and its use as a structural indication of informativity (both alone and in interaction with word order).

CHAPTER 7

A FORMAL MODEL OF WORD ORDER AS STRUCTURAL INDICATION OF INFORMATIVITY

In this chapter we develop grammar architectures that model the use of word order as structural indication of informativity on the basis of the distinctions of rigid, mixed and free word order as discussed in Chapter 6. Principal to our formal account is the view of adjacency as parameter (Moortgat and Oehrle, 1994). The results of this chapter are grammar architectures of basic strategies to realize information structure in VX, XV, and SVO languages, controlled by the informativity hypotheses. The core of these architectures is formed by architectures of rigid, mixed and free word order, controlled by the variation hypotheses.

7.1 INTRODUCTION

The cross-linguistic perspective on word order that we developed in the preceding chapter has been formulated independent of any particular grammar framework. In principal one could thus take the framework of one's liking to implement these ideas. Here, we naturally focus on we could use DGL. The goal of this chapter is to model word order as a structural indication of informativity. To that end I provide grammar architectures that describe basic forms of variability in word order, and show how information structure can control word order variation. The account is based on the relation between contextual boundness and systemic ordering (Chapter 5), and exploits the view of adjacency as a parameter (with information structure/contextual boundness as an important factor besides well-formedness).

Below I first provide a brief survey of proposals for using categorial grammar to model word order phenomena up to free word order. As we already pointed out earlier in Chapter 5, the combinatory tradition adheres to a Principle of Adjacency – only string-adjacent words can be combined. A direct consequence of this principle is that variability must to be modelled in the *lexicon*. To model variability we have to use categories that lexically define flexibility to the directions in which arguments are taken.

The combinatory approach differs in this from the logical tradition, where we conceive of adjacency as a *parameter*. Lexical categories define canonical word order. Variability in word order is achieved through the application of structural rules that have the possibility to alter the tree-structure. The application of structural rules is controled by the configuration of the tree-structure, and possibly any features that individual nodes carry. For one, that enables us to create a very fine-grained account where possible variation in word order can be conditioned on contexts that are larger than individual words. Another consequence is that we can use contextual boundness as a parameter to control structural rules modelling word order, and have the relation between surface form and underlying linguistic meaning/information structure defined compositionally by the Curry-Howard correspondence that holds for the calculus in general.

In §7.3 I work out a proposal for capturing word order in DGL. We present models of word order-based strategies for realizing information structure, as predicted by the informativity hypotheses presented in Chapter 6. These strategies structurally control more fundamental grammar architectures that model the basics of rigid, mixed, and free word order in VX, XV, and SVO languages.[1] In other words, the structural control formally implements the view that variability in word order is paramatrized by the information structure to be realized.

7.2 MODELS OF FLEXIBLE WORD ORDER IN CATEGORIAL GRAMMAR

The purpose of the current section is to provide a brief survey of proposals for using categorial grammar to model word order phenomena up to free word order. What the categorial grammar proposals discussed here, and the DGL proposal in §7.3, have in common is that they employ a *flexible* notion of surface structure in a setting that has a generative power stronger than context-freeness. It needs little argumentation that classical (context-free) phrase-structure grammar is wholly inadequate to explain variation in word order. To 'allow' for variation, alternate rules would have to be given that describe the other possible orders. However, as soon as variation

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[1] For reasons of conciseness, we present the formulation of these models without the $\Box^{\downarrow}{}_{inf}$ feature. In the underlying architecture used for the information structure architectures this feature is of course present, and used for controlling word order.

involves discontinuity (of any type) there is no way to describe it since we cannot relate the displaced elements to the site where they would normally be located. Finally, any generalization we can make *over* possible orders cannot be expressed in a phrase-structure grammar.

Below we start with proposals that have been developed in the combinatory tradition in categorial grammar: Steedman's CCG (1996; 2000c), Hoffman's MCCG (1995b; 1995a), and Baldridge's Set-CCG (1998; 1999) and modalized CCG, (2000). Thereafter, we briefly address various discussions of word order by Moortgat & Oehrle, set in categorial type logic.[2]

7.2.1 STEEDMAN'S CCG

Combinatory Categorial Grammar (CCG) was first introduced by Ades and Steedman in (1982) as a generalization of the earlier categorial grammar frameworks of Adjukiewicz and Bar-Hillel, and was later greatly expanded by Steedman in for example (1996; 2000c). At the heart of CCG we find a set of *combinators* that define composition. In CCG, the combinators are perceived of as *rule schemata* whose instantiation can be fine-tuned to the setting of a particular language, but which are otherwise the sole means by which we can -or need to- model composition across languages. The schemata thus have a certain cross-linguistic flavor, and Steedman has gone to great lengths showing that one can indeed employ the combinators to model a variety of languages. The variation in the instantiations of the schemata is then explainable with reference to language typology. An interesting example of such explanation is Steedman's (2000c) discussion of the treatment of dependent clause word order in Dutch, German, and English.[3]

CCG's combinators are based on the work of Curry and Feys, and were originally intended for to model the λ-calculus. A crucial difference between CCG's combinators and their original counterparts is, though, that the (recursive) application of the former are restricted. This limits the power of CCG *pur sang* and is the main reason why Vijayashanker and Weir are able to show in (1994) that CCG is mildly context-sensitive and parseable in

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[2] We do not discuss Hepple's (1990) proposal as it got superceded by his own later work on head/dependent asymmetries in categorial type logic (1994; 1996b; 1997), which we discussed already in Chapter 4.

[3] Furthermore, see (Kruijff and Baldridge, 2000) for a brief cross-linguistic comparison regarding the availability of particular combinators in Dutch, English, German, and Portuguese.

polynomial time.[4]

More precisely, we can define CCG's combinators as follows (Steedman, 2000c). CCG extends the Adjukiewicz-Bar-Hillel calculus (AB) by adding rules of syntactic combination which correspond to directionally specific forms of Curry and Feys' composition (B), type-raising (T), and substitution (S) combinators. These combinators are defined by the following equivalences on predicate-argument structures:

(392) a. $\mathbf{B}fg \equiv \lambda x.f(gx)$
b. $\mathbf{T}x \equiv \lambda f.fx$
c. $\mathbf{S}fg \equiv \lambda x.fx(gx)$

Definition 20 (Combinatory rules for CCG). *CCG extends its rule set beyond the function application rules of AB as follows:*

(393) Rules corresponding to $\mathbf{B}$*.*
a. $>\mathbf{B}:\ \mathsf{X/Y} : f \quad \mathsf{Y/Z} : g \ \Rightarrow_{\mathbf{B}}\ \mathsf{X/Z} : \lambda x.f(g'x)$
b. $>\mathbf{B}_{\times}:\ \mathsf{X/Y} : f \quad \mathsf{Y\backslash Z} : g \ \Rightarrow_{\mathbf{B}}\ \mathsf{X\backslash Z} : \lambda x.f(g'x)$
c. $<\mathbf{B}:\ \mathsf{Y\backslash Z} : g \quad \mathsf{X\backslash Y} : f \ \Rightarrow_{\mathbf{B}}\ \mathsf{X\backslash Z} : \lambda x.f(g'x)$
d. $<\mathbf{B}_{\times}:\ \mathsf{Y/Z} : g \quad \mathsf{X\backslash Y} : f \ \Rightarrow_{\mathbf{B}}\ \mathsf{X/Z} : \lambda x.f(g'x)$

(394) Rules corresponding to $\mathbf{T}$*.*
a. $>\mathbf{T}:\ \mathsf{X} : a \ \Rightarrow_{\mathbf{T}}\ \mathsf{Y/(Y\backslash X)} : \lambda f.fa$
b. $<\mathbf{T}:\ \mathsf{X} : a \ \Rightarrow_{\mathbf{T}}\ \mathsf{Y\backslash (Y/X)} : \lambda f.fa$

(395) Rules corresponding to $\mathbf{S}$*.*
a. $>\mathbf{S}:\ \mathsf{X/Y/Z} : f \quad \mathsf{Y/Z} : g \ \Rightarrow_{\mathbf{S}}\ \mathsf{X/Z} : \lambda x.fx(g'x)$
b. $>\mathbf{S}_{\times}:\ \mathsf{X/Y\backslash Z} : f \quad \mathsf{Y\backslash Z} : g \ \Rightarrow_{\mathbf{S}}\ \mathsf{X\backslash Z} : \lambda x.fx(g'x)$
c. $<\mathbf{S}:\ \mathsf{Y\backslash Z} : g \quad \mathsf{X\backslash Y\backslash Z} : f \ \Rightarrow_{\mathbf{S}}\ \mathsf{X\backslash Z} : \lambda x.fx(g'x)$
d. $<\mathbf{S}_{\times}:\ \mathsf{Y/Z} : g \quad \mathsf{X\backslash Y/Z} : f \ \Rightarrow_{\mathbf{S}}\ \mathsf{X/Z} : \lambda x.fx(g'x)$

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[4] As such, CCG could be set apart from categorial type logics. The latter are Turing Complete, as Carpenter showed in (1995), *if they are not restricted.* Like CCG's restriction leads to its more constrained behavior, so there exists the possibility to restrict categorial type logic though. We proved in (Kruijff and Baldridge, 2000) that we can construct a formal bisimulation of CCG in a categorial type logic fragment, with the fragment having a (weak) equivalence to CCG. Conversely, the article shows that a logical interpretation of CCG *is* possible, countering for example Morrill's criticism in (1994).

CCG as such cannot be used to model free word order, and exactly for that reason offsprings as MCCG and Set-CCG have been introduced. Yet, CCG can be successfully applied to model phenomena found in mixed word order languages, like cross-serial dependencies in Dutch, cf. (Steedman, 2000c), Chapter 6 for more detail.[5]

7.2.2 HOFFMAN'S MULTISET-CCG

In (1995a; 1995b) Hoffman introduces *multiset combinatory categorial grammar* (MCCG), an extension of CCG to deal with free word order. The basic idea behind MCCG is to relax the subcategorization requirements of a verb such that it no longer *needs* to specify the linear order in which the arguments have to occur. Rather, a verb is assigned a function category that takes a multiset of arguments[6] which are not necessarily assigned any directionality. For example, in MCCG we specify the category of a transitive verb as $S|\{N_{Nom}, N_{Acc}\}$. The verb takes a subject N_{Nom} and a direct object N_{Acc}, *in any order*, resulting in a construction of category S (sentence).

To be able to combine a function and its argument in any order, MCCG cannot employ the standard rules for functional application. Instead, we have (396).

(396) a. **Forward application** (>):
$X|(Args \cup \{Y\}) \quad Y \Rightarrow X|Args$
b. **Backward application** (<):
$Y \quad X|(Args \cup \{Y\}) \Rightarrow X|Args$

With the rules as in (396), we can combine a verb and its arguments in *any* order. To obtain a semantics, MCCG co-indexes the category's arguments with the arguments in the predicate structure. The reason being that we can no longer use ordinary λ-calculus due to the insensitivity to the order in which arguments are taken. For example, the category for a transitive verb like *read* would become $S : read(\boxed{1}, \boxed{2})|\{N_{Nom} : \boxed{1}, N_{Acc} : \boxed{2}\}$.

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[5] There are fundamental differences between Steedman's account and how we model cross-serial dependencies in DGL. Steedman assumes that the basic word order of Dutch matrix clauses is VSO, and that of dependent clauses SOV. Accordingly, verbs are assigned different lexical categories for use in matrix and dependent clauses. On the contrary, in DGL we first of all assume that Dutch matrix clause word order is SVO. Furthermore, there is no need to have several lexical categories for a verb to mirror its use at different clause levels.

[6] *Multiset*: a category of the same type may occur more than once in the same set.

For composition (**B**) we can define rules as in (397), using set-theoretic operations.

(397) a. **Forward composition** (>**B**):
$X|(Args_X \cup \{Y\}) \quad Y|Args_Y \Rightarrow X|(Args_X \cup Args_Y)$

b. **Backward composition** (<**B**):
$Y|Args_Y \quad X|(Args_X \cup \{Y\}) \Rightarrow X|(Args_X \cup Args_Y)$

With these composition rules, MCCG can handle for example free word order of sentential adjuncts ($S|\{S\}$). Also, by allowing multiple verbs to compose using **B**, MCCG can analyze complex sentences with embedded clauses.

Quite naturally, the question arises how all this freedom can be controlled, or restricted. For example, Japanese allows for a free ordering of arguments but is otherwise rigidly verb-final. We can represent this in MCCG by attaching a "directional feature" to arguments: $S|\{\overleftarrow{N}_{case=Nom}, \overleftarrow{N}_{case=Acc}\}$. To make composition sensitive to these directional features, we require that in $\{<, <\mathbf{B}\}$ the Y argument of X is marked as $\overleftarrow{Y}$, and that in $\{>, >\mathbf{B}\}$ it is marked as $\overrightarrow{Y}$. It remains an open issue, though, whether more fine-grained restrictions can be captured in this way as well - for example, the occurrence of Czech clitics in the Wackernagel position, a criticism mentioned in (Kruijff, 1999a). Furthermore, there are substantial difficulties with the relation between information structure and word order in MCCG. As I already mentioned in Chapter 5 (p.180ff.), the Principle of Adjacency forces one to model not only variability of word order but also its effect as structural indication of informativity elsewhere than in the rule component. Variability can be modelled in the lexicon, but the effect of word order as a structural indication of informativity cannot. In MCCG, this eventually leads more or less to a dissociation of information structure from word order, contrary to general linguistic intuitions.

7.2.3 BALDRIDGE'S SET-CCG, MODALIZED CCG

Baldridge presents in (1998; 1999) a framework that incorporates ideas found in Hoffman's MCCG but that at the same time retains the formal and computational strengths of CCG. Next to Set-CCG, Baldridge proposes in (2000) a version of CCG that distinguishes different modes of composition like categorial type logic does, based on (Kruijff and Baldridge, 2000). Here, we present both Set-CCG and modalized CCG. The reason for discussing modalized CCG is that, due its affinity with categorial type logic, it seems envisionable to extent modalized CCG to cover Set-CCG and then use this "modal-Set-CCG" to overcome the problems noted for multiset combinatory categorial grammar.

Just like MCCG, Set-CCG enables one to express that particular arguments can be combined with in any order. However, unlike MCCG, Set-CCG categories retain the specification of directionality (unlike MCCG's $|$) so that Set-CCG's categories in general look a lot more like the original CCG categories. For example, the category for a transitive verb (with basic SOV order) is $S\backslash\{N_{nom}, N_{acc}\}$. Then, occurring left of the head, both arguments can be combined in any order using $<$ (Definition 21).

Definition 21 (Set-CCG). *The rule schemata for the combinators are defined in Set-CCG as follows.*

(398) *a.* ***Backward application(<):***
$Y \quad X\backslash(\alpha \uplus \{Y\}) \;\Rightarrow\; X\backslash\alpha$
b. ***Forward application:(>):***
$X/(\alpha \uplus \{Y\}) \quad Y \;\Rightarrow\; X/\alpha$

(399) *a.* ***Backward composition:***
$Y\backslash(\beta \uplus \gamma) \quad X\backslash(\alpha \uplus \{Y\backslash\beta\}) \;\Rightarrow\; X\backslash\alpha\backslash\gamma$
b. ***Forward composition:***
$X/(\alpha \uplus \{Y/\beta\}) \quad Y/(\beta \uplus \gamma) \;\Rightarrow\; X/\alpha/\gamma$

(400) *a.* ***Backward type-raising:***
$X \;\Rightarrow\; T\backslash\{T/\{X\}\}$
b. ***Forward type-raising:***
$X \;\Rightarrow\; T/\{T\backslash\{X\}\}$

Remark 21 (Rigidification and Set-CCG's power). An important point to note about Set-CCG is its *rigidification* of slash-directionality. For the purpose of economy, we are allowed to use the "up-down" slash $|$ to specify categories, but once *one* argument from a $|$'d bag is taken in a particular direction, then *all* arguments have to be combined with in that direction. Thus, $S|\{N_s, N_o\}$ can take either take its arguments all to the right, in any order, so that we get a rigid head-initial structure. Or, we can combine with all arguments to the left.

In other words, Set-CCG allows for scrambling of the *arguments*, but not of the head itself. The head remains in a fixed position, and it is this rigidification that makes it possible for Set-CCG to have the same generative strenght and parseability as CCG.

⊛

Besides Set-CCG, Baldridge has also proposed *modalized CCG*, based (Kruijff and Baldridge, 2000). Below, we first briefly describe the intentions behind (Kruijff and Baldridge, 2000), and then explain how Baldridge employs it to create modalized CCG.

Our goal in (Kruijff and Baldridge, 2000) is twofold. Firstly, we try to establish a fragment in categorial type logic that accepts *exactly* the same structures as CCG can allow for. The fragment can thus serve as a logical interpretation of CCG, countering Morrill's criticism levelled against CCG in (1994)(for example, cf. p.257). Secondly, by proving that the fragment is an exact simulation of CCG, we also obtain a (weak) generative equivalence to CCG's mild context-sensitivity and the possibility to parse with the fragment in polynomial time (Vijayashanker and Weir, 1994). Hence, the fragment illustrates how one can employ a restricted form of commutativity that does not lead to a collapse, and which gives rise to a linguistically interesting generative strength. Concisely, the simulation can be defined as follows.

Definition 22 (A simulation of CCG). *The CCG-equivalent fragment defined by (Kruijff and Baldridge, 2000) uses modalities* $\{\triangleleft, \triangleright\}$*, the base standard logic* NL*, and the following structural rules for simulating application* $(<, >)$*, composition (*B*), and type raising (*T*).*

(401) ***Right Associativity:***

$$\frac{(\mathbf{A} \ \diamond \ (\mathbf{B} \triangleright \mathbf{C})) \vdash \mathsf{X} : \sigma}{((\mathbf{A} \ \diamond \ \mathbf{B}) \triangleright \mathbf{C}) \vdash \mathsf{X} : \sigma} RA$$

(402) ***Left Associativity:***

$$\frac{((\mathbf{A} \ \diamond \ \mathbf{B}) \triangleright \mathbf{C}) \vdash \mathsf{X} : \sigma}{(\mathbf{A} \ \diamond \ (\mathbf{B} \triangleright \mathbf{C})) \vdash \mathsf{X} : \sigma} LA$$

(403) ***Right Commutativity:***

$$\frac{((\mathbf{A} \triangleright \mathbf{B}) \triangleleft \mathbf{C}) \vdash \mathsf{X} : \sigma}{((\mathbf{A} \triangleleft \mathbf{C}) \triangleright \mathbf{B}) \vdash \mathsf{X} : \sigma}[RP]$$

(404) ***Left Commutativity:***

$$\frac{(\mathbf{A} \triangleright (\mathbf{B} \triangleleft \mathbf{C})) \vdash \mathsf{X} : \sigma}{(\mathbf{B} \triangleleft (\mathbf{A} \triangleright \mathbf{C})) \vdash \mathsf{X} : \sigma}[LP]$$

The base logic naturally models $<, >$. *The rules for associativity enable us to simulate* $<\mathbf{B}, >\mathbf{B}$, *whereas we need the additional, limited form of commutativity to handle* $<\mathbf{B}_\times, >\mathbf{B}_\times$. *We do not need any other rules, as type raising is a theorem of* NL *already (Oehrle, 1994).* ⊛

To define the modalized version of Combinatory Categorial Grammar, Baldridge redefines the rules of CCG (Definition 20) to respect the modal behavior of the rules which we use to simulate them. Furthermore, Baldridge defines the set of modalities to be $\{\star, \triangleleft, \triangleright\}$ and uses two variable modes $\{\circ, \diamond\}$, where $\circ \in \{\star, \triangleleft, \triangleright\}$ and $\diamond \in \{\triangleleft, \triangleright\}$.

Definition 23 (Modalized CCG). *The rules for modalized CCG are as follows. Note that the semantics of the rules are the same as given in (392) for pure CCG and are thus omitted.*

(405) *The CCG 'base logic'.*

a. $(>) : \mathsf{X}/_\circ\mathsf{Y} \quad \mathsf{Y} \;\Rightarrow\; \mathsf{X}$

b. $(<) : \mathsf{Y} \quad \mathsf{X}\backslash_\circ\mathsf{Y} \;\Rightarrow\; \mathsf{X}$

(406) ***Composition***

a. $(>\mathbf{B}) : \mathsf{X}/_\diamond\mathsf{Y} \quad \mathsf{Y}/_\triangleright\mathsf{Z} \;\Rightarrow_{\mathbf{B}}\; \mathsf{X}/_\triangleright\mathsf{Z}$

b. $(<\mathbf{B}) : \mathsf{Y}\backslash_\triangleleft\mathsf{Z} \quad \mathsf{X}\backslash_\diamond\mathsf{Y} \;\Rightarrow_{\mathbf{B}}\; \mathsf{X}\backslash_\triangleleft\mathsf{Z}$

(407) ***Crossing composition***

a. $(>\mathbf{B}_\times) : \mathsf{X}/_\triangleright\mathsf{Y} \quad \mathsf{Y}\backslash_\triangleleft\mathsf{Z} \;\Rightarrow_{\mathbf{B}}\; \mathsf{X}\backslash_\triangleleft\mathsf{Z}$

b. $(<\mathbf{B}_\times) : \mathsf{Y}/_\triangleright\mathsf{Z} \quad \mathsf{X}\backslash_\triangleleft\mathsf{Y} \;\Rightarrow_{\mathbf{B}}\; \mathsf{X}/_\triangleright\mathsf{Z}$

(408) ***Type-raising***

a. $(>\mathbf{T}) : \mathsf{X} \;\Rightarrow_T\; \mathsf{Y}/_\circ(\mathsf{Y}\backslash_\circ\mathsf{X})$

b. $(<\mathbf{T}) : \mathsf{X} \;\Rightarrow_T\; \mathsf{Y}\backslash_\circ(\mathsf{Y}/_\circ\mathsf{X})$

As said, type-raising is a theorem of NL, *but we need to explicitly state it for Combinatory Categorial Grammar. We permit any modality to decorate the slashes which are created in order to mimic the behavior of* NL. ⊛

7.2.4 MODELS OF WORD ORDER IN CTL

Over time, there have been various proposals for dealing with word order-related phenomena in the Lambek tradition. With the realization that a context-free framework does not suffice to explain for example discontinuous constructions like long-distance dependencies, people turned their attention to the Lambek-Van Benthem calculus LP. LP is a calculus that is fully associative and commutative - thus allowing for a much freer ordering.

Worse, LP actually allows for *any* ordering. Thus, obviously, this calculus is too strong and, due to its context freeness, the original Lambek calculus L (Lambek, 1958) is too weak. An intermediate position between L and LP would be ideal. Just adding commutativity to L precipitates a collapse to LP, as Moortgat (1988) shows. Control thus turns out to be the keyword.

Early proposals for *structural control* involved the use of unary modal operators like $\triangle$, $\Box$, or $\Diamond$ - for example, see Moortgat's (1988; 1996), Hepple's (1990), or Morrill's (1994). Appropriately marked words or structures license the application of structural rules that involve -for example- the use of commutativity. Because structural rules thus no longer necessarily apply to all structures but only to specific configurations, we can gain a generative strength that goes beyond the ordinary Lambek calculus without collapsing to LP.

From the technical viewpoint, Kurtonina and Moortgat show in (1996) that the thus evolving landscape of substructural proof logics behaves nicely, having characteristics like completeness and soundness. More importantly, Moortgat & Oehrle discuss in their important paper "Adjacency, dependency, and order" (1994) what the categorial type logical perspective on word order in fact amounts to from a linguistic point of view.

The point that Moortgat & Oehrle advance is that adjacency is a *parameter* of resource structuring. Structural rules can be used to reconfigure structures such that elements that used to be non-adjacent, now do become adjacent. Thus, adjacency is not considered to be a necessary condition for composition, but is something that can be brought about. This view stands in sharp contrast to Steedman's *Principle of Adjacency* for CCG. According to that principle, only string-adjacent entities may be combined (cf. (Steedman, 2000c),p.54). When dealing with adjacency as a parameter, Moortgat & Oehrle point out that there are essentially two situations that one might face (409).

(409) a. $(\Gamma[\Delta_1], \Delta_2) \rightsquigarrow \Gamma[(\Delta_1, \Delta_2)]$

b. $\Gamma[(\Delta_1, \Delta_2)] \rightsquigarrow (\Gamma[\Delta_1], \Delta_2)$

Each structural rule specifies the configuration we encounter (the LHS), and the configuration that is required for the rule to apply (the RHS). Clearly, the two cases in (409) are symmetric. In (409a) we find that Δ_2 is combined with Γ whereas it should find its proper place with a substructure of Γ, namely Δ_1; (409b) presents the opposite 'movement'.[7] Moortgat & Oehrle characterize (409a) as case of a dependent Δ_2 being *attracted* by the head Δ_1, whereas (409b) illustrates the case of Δ_2 *adjoining* itself to the head Δ_1.

Formally, Moortgat & Oehrle make use of structural rules that regulate the interaction between headedness (distinguishing a head-dependent asymmetry as proposed by Moortgat & Morrill in (1991)) and adjacency. Axiomatically, this type of interaction is captured -abstractly- by axioms that define how *different* modes are commutative and associative with respect to one another:

(410) **Interaction - Mixed commutativity**:

$((A \circ_i B) \circ_j C) \longleftrightarrow ((A \circ_j C) \circ_i C)$

(411) **Interaction - Mixed associativity**:

$((A \circ_i B) \circ_j C) \longleftrightarrow (A \circ_i (B \circ_j C))$

The j mode generically represents a mode of composition that enables non-adjacency, whereas i models adjacent composition in terms of a heads and dependents. Thus, the rules in (410) and (411) are schemata: Moortgat & Oehrle obtain models for specific constructions by appropriately instantiating i, j. Moortgat & Oehrle discuss two examples that illustrate the head-wrapping type of construction in (409a) and the head-attraction of (409b).

We can briefly characterize the understanding of head wrapping explored in (Moortgat and Oehrle, 1994) as follows. Head wrapping enables to ele-

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[7] A brief remark about 'movement': Like Steedman points out in the introduction to (1996), we use 'movement' here *metaphorically* and *not* in the sense of Chomskyan linguistics. There is no equivalent of "move-α" or alike in categorial type logic, because of a different relation to logical form. We do admit though that, 'despite' adhering to a metaphorical sense of movement, the structural rules dealing with word order do have a flavor of moving elements around. It is perhaps noteworthy that precisely because of that flavor, categorial type logic has been used as a tool to model Minimalism.

ments to become adjacent, starting from a composition in which these two elements were *not* adjacent. Moortgat and Oehrle explain this using the terms *infix* and *circumfix* (or host): the infix syntactically adjoins itself to the head of the circumfix. More specifically, we have that the infix can go before or after the head of the host, and can either determine the head of the construction (endocentricity) or combine as a dependent (exocentricity). Consequently, Moortgat & Oehrle distinguish four "wrapping" modes, labelled lh, ld, rh, rd with $l(r)$ indicating that the infix is to the left (right), and with $h(d)$ indicating that the infix (circumfix) determines the head of the construction.

The interesting aspect about the model that Moortgat & Oehrle then present is their distinction between *bases cases* and *recursive cases.* The base cases tell us under what conditions head-wrapping is equivalent to simple dependency adjunction. On the other hand, the recursive cases establish the communication between the wrapping modes and dependency. They use instantiations of (410) and (411) to allow the infix to "travel" through a tree structure until it is at a landing site which is characterized by one of the base cases. Their model is given in (412). The mode $lw(rw)$ is a shorthand for lh or ld (rh or rd).

(412) MOORTGAT AND OEHRLE'S MODEL OF HEAD WRAPPING

a. **Base cases**:

A1: $A \circ_l B \longrightarrow A \circ_{lh} B$ A1': $A \circ_r B \longrightarrow A \circ_{ld} B$
A2: $A \circ_l B \longrightarrow A \circ_{rd} B$ A2': $A \circ_r B \longrightarrow A \circ_{rh} B$

b. **Recursive cases**:

A3: $((A \circ_{rw} B) \circ_l C) \longrightarrow ((A \circ_l C) \circ_{rw} B)$
A4: $(A \circ_r (B \circ_{rw} C)) \longrightarrow ((A \circ_r B) \circ_{rw} C)$
A5: $(A \circ_r (B \circ_{lw} C)) \longrightarrow (B \circ_{lw} (A \circ_r C))$
A6: $((A \circ_{lw} B) \circ_l C) \longrightarrow (A \circ_{lw} (B \circ_l C))$

Moortgat & Oehrle apply their model to Dutch verb raising, and in their discussion they briefly reflect on how their model differs from Steedman's CCG. As we already pointed out earlier, CCG models cross-serial dependencies in Dutch using crossed composition, $<\mathbf{B}_\times$ and $>\mathbf{B}_\times$. Although these combinators are obviously not valid in L, the structures they allow for are theorems of LP. However, if we would indeed model crossed composition purely as LP, then any directional variant would do.

Steedman restricts possible rule schemata by means of two principles: the principle of *Directional Consistency* and the principle of *Directional Inheritance* - cf. (1996), p.42ff. It follows from these two principles that *any* rule in CCG needs to obey, or project, the directionality specified in the lexicon. On the other hand, the model in (412) restricts the possible orderings directly in terms of the logic. The orders possible on the basis of $<\mathbf{B}_{\times}, >\mathbf{B}_{\times}$ are derivable as theorems of (412), [8] as do the principles - there is no need for their meta-theoretical stipulation.

Moortgat & Oehrle also briefly discuss the second case, head attraction (409b). We do not repeat their entire discussion here, as Moortgat & Oehrle only present fragments to deal with particular cases of head attraction in Dutch and English. Rather, we just note a few interesting observations about their fragments. For example, associativity ("re-bracketing") provides the formal means to block recursion up or down trees, yielding empirical consequences like the Right Roof constraint or the (im)possibility of dangling prepositions. Furthermore, island constraints can be modelled modelled by combining a head-dependent asymmetry with associativity.

To conclude, Moortgat & Oehrle's models of head wrapping and head adjunction provide an interesting example of how word order can be modeled in categorial type logic. Theirs is, naturally, not the only proposal that has been advanced - but it bears a close resemblance to for example Hepple's later work (1996b; 1997), and it provides more detail than Foster's (1992).

Unsurprisingly, the types of structural rules that Moortgat & Oehrle employ are similar to the ones we find in the simulations of CCG (Kruijff and Baldridge, 2000) as presented above. This underlines the observation we make in (Kruijff and Baldridge, 2000), namely that the differences between the combinatory tradition and the Lambek tradition are for a large part a matter of *perspective*. Here, we naturally stay within the Lambek tradition - but it is not inconceivable that DGL's model of word order to be presented below can be more or less directly translated into for example a modalized version of Set-CCG.

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[8] In fact, they are derivable on even simpler structural rules that are close to (410) and (411), as we show in (Kruijff and Baldridge, 2000).

7.3 VARIABILITY OF WORD ORDER IN DGL

Our aim in the present section is to develop a model of basic phenomena we find in variability in word order. Particular about the model is that it has an *architecture*. The architecture gives the model an internal structure that determines a precedence, or interdependence, among structural rules. Figure 7.1 gives an overview of the architecture. Many of the decision points in the architecture are covered by the variation hypotheses of Chapter 6 or the data as such.[9] The architecture in Figure 7.1 provides the foundations on which we build our models of word order as a structural indication of informativity, see §7.4.

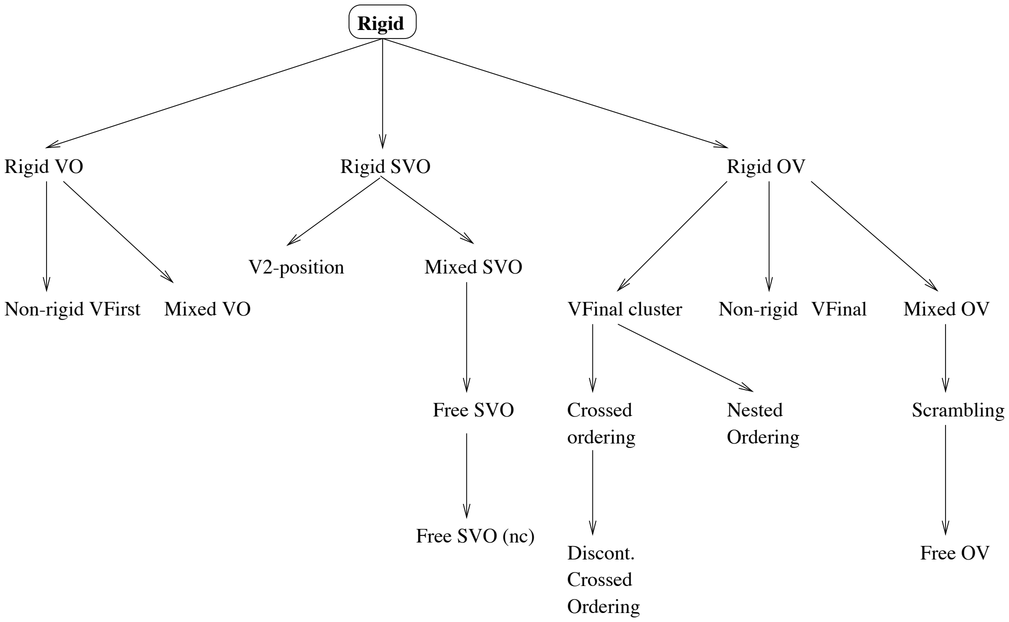

Figure 7.1: The architecture of DGL's word order model

For example, consider the branching under **Rigid OV**. We have several options here, concerning verb final clustering, non-rigid OV behavior, and scrambling. To illustrate how we work with the architecture, consider the subordinate clause constructions in Dutch, Flemish, and German in (413) through (415).

(413) **Dutch**, **Flemish**

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[9] The only decisions not covered concern non-rigidity in verb-finality, and when a language has cross-serial or nested long-distance dependencies.

omdat Christopher Kathy boeken wil leren lezen.
because Christopher kath books wants to be teach to read.

English "Because Christopher wants to be teach Kathy to read books."

(414) a. **Dutch** omdat Christopher Kathy boeken wil leren lezen.
b. **Flemish**,**Dutch*** omdat Christopher wil Kathy boeken leren lezen.
c. **Flemish**,**Dutch*** omdat Christopher wil Kathy leren boeken lezen.

(415) a. **German** weil Christopher Kathy Bücher zu lesen beibringen möchte.

As we already discussed earlier, subordinate clauses have a different dominant word order from matrix clauses - the former are SOV, whereas the latter as SVO. In the examples above we see that all three languages display verb raising, leading to verb final clusters. What the grammars for these languages thus can be thought *to have in common* is a package of structural rules VFinalCluster that enforces the clause-final ordering of verbs in subordinate clauses. But, continuing this line of thought, once the verbs are clustered at the end, the languages *differ* in how the verbs are to be *ordered.* Both Dutch and Flemish share a further package CrossedOrdering, on top of VFinalCluster, that leads to an ordering giving rise to cross-serial dependencies. German does not have such a package, but instead has -in addition to VFinalCluster- a package NestedOrdering (shared with for example Japanese) that orders the verbs in such a way that we get nested dependencies.

Thus, to sum up, we can "instantiate" the relevant part of the architecture as in Figure 7.2. Naturally, once we have defined the mentioned packages of structural rules, we can recast the picture as a cross-linguistic network like we discussed in Chapter 4.

7.3.1 PRELIMINARIES TO THE FORMULATION OF THE PACKAGES

Before we get to the formulation of the packages of structural rules, I need to clarify a few general strategies that I follow. First of all, following Moortgat (1999) and Steedman (1996; 2000c) we distinguish different *clause levels* by means of features. The relevant unary modal operators are given in (416).

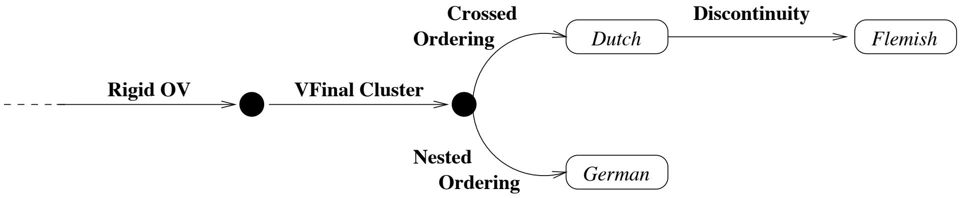

Figure 7.2: Dutch, Flemish and German verbraising

(416) a. $\Box^{\downarrow}{}_{cls}$, clause level, $cls \subseteq \{mtx, sub\}$.
b. $\Box^{\downarrow}{}_{mtx}$, matrix clause level, $mtx \supseteq cls$
c. $\Box^{\downarrow}{}_{sub}$, subordinate clause level, $sub \supseteq cls$

The different unary modal operators in (416) help us to obtain a modularity in defining structural rules. Constraints on the required ordering at a particular clause level can then obtained by a linkage rule like $\langle A\rangle^{sub} \longrightarrow \langle A\rangle^{vfinal}$, which specifies that the order in subordinate clause is verb-final.

Secondly, I adhere to a particular encoding of the formal names of the structural rules discussed here. The general format is PackageName [.SubPackage] Number . Description, whereby Description can take the following form: $m(x)$= "move" structure x, $p(f, md)$= "percolate" feature f over mode md, $d(f, md)$= "distribute" feature f over mode md. For example, VFinal.XDep1.p(vhead,mod) is a rule in the *Crossed Dependencies* (XDep) subpackage of the *Verb-Final Cluster* (VFinal) package, specifying the percolation of the *vhead* feature over a structure built using mode *mod*. These formal names are used in proofs, but we -naturally- give a more elaborate description of the ideas behind each rule when introducing it.

Finally, to keep the definitions of the packages reasonably short, we usually omit statements of structural rules for modes other than *sc*, *dc*, and *ic* - like *c*, *tma* or *spa*. Rules for the latter modes are simply different instantiations of the same structure as used for *sc*, *dc*, and *ic*.

7.3.2 OV PACKAGES

The OV packages define behavior that is, possibly, available in languages that have OV as dominant word order at some or all clause levels. For example, Japanese displays OV behavior at both the matrix clause and the subordinate clause levels, whereas Dutch and German only use OV at the subordinate clause level, having SVO as the dominant order of the matrix clause.

Below we present the various packages relevant to modeling aspects of OV word order. Naturally, a language only employs a proper *subset* of these packages. Moreover, even when a language does employ a particular package it need not be the case that all rules are used - for example, if a language has no modal auxiliaries, any rule defining the behavior of the *mod* mode is superfluous.[10]

The architecture in Figure 7.1 in fact shows what packages can be taken in conjunction (&) and which only in (exclusive) disjunction (∨). Thus, a language usually either has Crossed Dependencies or Nested Dependencies.

The modeling of OV word order starts from the assumption that we have lexical function categories that take their arguments to the left. For example, with *Subj* the subject, *DObj* the direct object, and *Verb* the verb, we have the following template-like structures for OV:

(417) Prototypical OV canonical structure: $(Subj \circ_{\prec sc} (DObj \circ_{\prec dc} Verb))$

Definition 24 (Verb Final Clusters, (VFinal)). *The VFinal package defines the ordering of verbs towards the end of a clause. The exact ordering is of verbs* within *the cluster is defined in the packages XDep, NDep, and MxDep depending on language-specific behavior. All these packages extend the behavior specified by VFinal. The VFinal package comprises the rules given in (418).*

$$\textit{(418)}\quad \begin{array}{rcll}
\langle A\rangle^{sub} & \rightarrow & \langle A\rangle^{vfinal} & [Sub\ is\ vfinal] \\
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{vfinal} & [Matrix\ is\ vfinal] \\
A \circ_{<sc} \langle B\rangle^{vfinal} & \rightarrow & A \circ_{<sc} \langle B\rangle^{vhead} & [VFinal0.l(vhead, vfinal)] \\
A \circ_{<dc} \langle B\rangle^{vfinal} & \rightarrow & A \circ_{<dc} \langle B\rangle^{vhead} & [VFinal0.l(vhead, vfinal)] \\
A \circ_{<ic} \langle B\rangle^{vfinal} & \rightarrow & A \circ_{<ic} \langle B\rangle^{vhead} & [VFinal0.l(vhead, vfinal)] \\
\langle A \circ_{<sc} B\rangle^{vfinal} & \rightarrow & A \circ_{<sc} \langle B\rangle^{vfinal} & [VFinal1.p(vfinal, < sc)] \\
\langle A \circ_{<dc} B\rangle^{vfinal} & \rightarrow & A \circ_{<dc} \langle B\rangle^{vfinal} & [VFinal1.p(vfinal, < dc)] \\
\langle A \circ_{<ic} B\rangle^{vfinal} & \rightarrow & A \circ_{<ic} \langle B\rangle^{vfinal} & [VFinal1.p(vfinal, < ic)]
\end{array}$$

$\circledast$

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[10] At least, it is superfluous in the sense that it is not used in derivations for that language.

Remark 22 (Description of the VFinal package). The general strategy is as follows. For a clause to be well-formed, we in general require it to be either $\Box^{\downarrow}{}_{mtx}S$ (matrix clause) or $\Box^{\downarrow}{}_{sub}S$ (subordinate clause). In a language that has verb final ordering at a particular clause level, we include $[Sub\ is\ vfinal]$ or $[Matrix\ is\ vfinal]$ (or both) to mirror that requirement.

Each of these rules specifies that if a structure A is a particular type of clause (sub/mtx), then it has to be $vfinal$. Then, starting with the VFinal1 rules, we see that for a structure composed out of A and B to be $vfinal$, we need to have that the substructure B needs to be $vfinal$. Because of the direction of the headed modes (pointing $\prec$ to the dependent on the left), we know that the verbal head has to be to the right - corresponding to OV.

In the simplest case, defined by the VFinal0 rules, we have that the verb final cluster is formed by the verbal head itself. The examples in (419) illustrate such cases, whereas the derivation (420) shows how the goal category $\Box^{\downarrow}{}_{sub}S$ can be derived for subordinate clauses as in (419).[11]

(419) a. **Dutch**

...(dat) Christopher boeken leest
Christopher books reads

"... (that) Christopher reads books."

b. **German**

...(daß) Christopher Bücher leßt.
Christopher books reads

"... (that) Christopher reads books."

(420)

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{subj} \vdash \Box^{\downarrow}{}_{act}n \qquad \dfrac{\text{dobj} \vdash \Box^{\downarrow}{}_{pat}n \qquad \dfrac{\text{tverb} \vdash \Box^{\downarrow}{}_{vhead}(\Box^{\downarrow}{}_{pat}n\backslash_{<dc}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}s))}{\langle\text{tverb}\rangle^{vhead} \vdash \Box^{\downarrow}{}_{pat}n\backslash_{<dc}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)}[\Box^{\downarrow}E]}{\text{dobj} \circ_{<dc} \langle\text{tverb}\rangle^{vhead} \vdash \Box^{\downarrow}{}_{act}n\backslash_{<sc}s}[\backslash E]}{\text{subj} \circ_{<sc}(\text{dobj} \circ_{<dc} \langle\text{tverb}\rangle^{vhead}) \vdash s}[\backslash E]}{\text{subj} \circ_{<sc}(\text{dobj} \circ_{<dc} \langle\text{tverb}\rangle^{vfinal}) \vdash s}[VFinal0.l(vhead, vfinal)]}{\text{subj} \circ_{<sc}\langle\text{dobj} \circ_{<dc} \text{tverb}\rangle^{vfinal} \vdash s}[VFinal1.p(vfinal, < dc)]}{\langle\text{subj} \circ_{<sc}(\text{dobj} \circ_{<dc} \text{tverb})\rangle^{vfinal} \vdash s}[VFinal1.p(vfinal, < sc)]}{\langle\text{subj} \circ_{<sc}(\text{dobj} \circ_{<dc} \text{tverb})\rangle^{sub} \vdash s}[Sub\ is\ vfinal]}{\text{subj} \circ_{<sc}(\text{dobj} \circ_{<dc} \text{tverb}) \vdash \Box^{\downarrow}{}_{sub}s}[\Box^{\downarrow}I]$$

---

[11] Note that, for brevity, we gloss over any morphological strategies and functional interpretation.

Definition 25 (VFinal, Crossed Ordering (VFinal.XDep)). *The first extension to the VFinal package we consider here is the XDep package which models the type of ordering in a verbal cluster that gives rise to cross-serial dependencies. The XDep package comprises the rules as given in (421).*

(421)

$$\begin{array}{rcll}
B \circ_{<dc}(A \circ_{<mod} C) & \rightarrow & A \circ_{<mod}(B \circ_{<dc} C) & [VFinal.XDep0.m(mod)] \\
B \circ_{<dc}(A \circ_{<aux} C) & \rightarrow & A \circ_{<aux}(B \circ_{<dc} C) & [VFinal.XDep0.m(aux)] \\
B \circ_{<ic}(A \circ_{<mod} C) & \rightarrow & A \circ_{<mod}(B \circ_{<ic} C) & [VFinal.XDep0.m(mod)] \\
B \circ_{<ic}(A \circ_{<aux} C) & \rightarrow & A \circ_{<aux}(B \circ_{<ic} C) & [VFinal.XDep0.m(aux)] \\
B \circ_{<sc}(A \circ_{<per} C) & \rightarrow & A \circ_{<per}(B \circ_{<sc} C) & [VFinal.XDep0.m(per)] \\
B \circ_{<dc}(A \circ_{<per} C) & \rightarrow & A \circ_{<per}(B \circ_{<dc} C) & [VFinal.XDep0.m(per)] \\
B \circ_{<ic}(A \circ_{<per} C) & \rightarrow & A \circ_{<per}(B \circ_{<ic} C) & [VFinal.XDep0.m(per)] \\
\langle A \circ_{<aux} B\rangle^{vhead} & \rightarrow & A \circ_{<aux}\langle B\rangle^{vhead} & [VFinal.XDep1.p(vhead, aux)] \\
\langle A \circ_{<mod} B\rangle^{vhead} & \rightarrow & A \circ_{<mod}\langle B\rangle^{vhead} & [VFinal.XDep1.p(vhead, mod)] \\
\langle A \circ_{<per} B\rangle^{vhead} & \rightarrow & A \circ_{<per}\langle B\rangle^{vhead} & [VFinal.XDep1.p(vhead, per)]
\end{array}$$

⊛

Remark 23 (Description of the XDep package). The XDep package extends the VFinal package by determining the exact order of auxiliaries, modal verbs, modal infinitives and the verbal head (possibly an infinitive itself) in the verbal cluster. The XDep0 structural rules enable the cluster to be formed - and XDep1 imposes the *requirement* for that the ordering, extending the VFinal1 rules. The examples in (422) below illustrate in more detail the kind of phenomena covered by VFinal+XDep.

(422) a. **Dutch**

...(dat) Christopher Kathy wilde kunnen kussen.
Christopher Kathy wanted to be able to kiss

"...(that) Christopher wanted to be able to kiss Kathy."

b. **Dutch**

...(dat) Christopher Kathy Elijah zag willen kussen.
Christopher Kathy Elijah saw to want to kiss

"...(that) Christopher saw Kathy wanted to kiss Elijah."

Now let us have a closer look at the derivations. In the derivations, we make use of a slightly more abstract lexicon whose function categories are given in (423).

(423)

$$\begin{array}{l}
\mathrm{inf} : \Box^{\downarrow}{}_{vhead}(\Box^{\downarrow}{}_{pat}n\backslash_{<dc}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}sinf))\\
\mathrm{mod} : (\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)/_{<mod}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}sinf)\\
\mathrm{aux} : (\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)/_{<aux}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}sinf)\\
\mathrm{modi} : (\Box^{\downarrow}{}_{act}n\backslash_{<sc}sinf)/_{<mod}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}sinf)\\
\mathrm{tverb} : \Box^{\downarrow}{}_{vhead}(\Box^{\downarrow}{}_{pat}n\backslash_{<dc}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}s))\\
\mathrm{perc} : (\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)/_{<per}sinf
\end{array}$$

Then, for (422a) the derivation is as in (424). We leave out the first elimination steps, as these are trivial.

(424)

$$\begin{array}{cl}
\vdots & \\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{inf}\rangle^{vhead}))) \vdash s & [\backslash E]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{aux} \circ_{<aux}(\mathrm{dobj} \circ_{<dc}(\mathrm{modi} \circ_{<mod}\langle \mathrm{inf}\rangle^{vhead}))) \vdash s & [VFinal.XDep0.m(mod)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{aux} \circ_{<aux}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{modi} \circ_{<mod}\mathrm{inf}\rangle^{vhead})) \vdash s & [VFinal.XDep1.p(vhead, mod)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{aux} \circ_{<aux}\langle \mathrm{modi} \circ_{<mod}\mathrm{inf}\rangle^{vhead})) \vdash s & [VFinal.XDep0.m(aux)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}\mathrm{inf})\rangle^{vhead}) \vdash s & [VFinal.XDep1.p(vhead, aux)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}\mathrm{inf})\rangle^{vfinal}) \vdash s & [VFinal0.l(vhead, vfinal)]\\ \hline
\mathrm{subj} \circ_{<sc}\langle \mathrm{dobj} \circ_{<dc}(\mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}\mathrm{inf}))\rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < dc)]\\ \hline
\langle \mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}\mathrm{inf})))\rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < sc)]\\ \hline
\langle \mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}\mathrm{inf})))\rangle^{sub} \vdash s & [Sub\ is\ vfinal]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{aux} \circ_{<aux}(\mathrm{modi} \circ_{<mod}\mathrm{inf}))) \vdash \Box^{\downarrow}{}_{sub}s & [\Box^{\downarrow}I]
\end{array}$$

The example in (422b) illustrates Dutch cross-serial dependencies in a way it is usually found in the literature. The derivation in VFinal+XDep is given in (425).

(425)

$$\begin{array}{cl}
\vdots & \\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{perc} \circ_{<per}(\mathrm{subj} \circ_{<sc}(\mathrm{modi} \circ_{<mod}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{inf}\rangle^{vhead})))) \vdash s & [\backslash E]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{perc} \circ_{<per}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{modi} \circ_{<mod}\langle \mathrm{inf}\rangle^{vhead})))) \vdash s & [XDep0.m(mod)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{perc} \circ_{<per}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{modi} \circ_{<mod}\mathrm{inf}\rangle^{vhead}))) \vdash s & [XDep1.p(vhead, mod)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{perc} \circ_{<per}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{modi} \circ_{<mod}\mathrm{inf}\rangle^{vhead}))) \vdash s & [XDep0.m(per)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{perc} \circ_{<per}\langle \mathrm{modi} \circ_{<mod}\mathrm{inf}\rangle^{vhead}))) \vdash s & [XDep0.m(per)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf})\rangle^{vhead})) \vdash s & [XDep1.p(vhead, per)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}\langle \mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf})\rangle^{vfinal})) \vdash s & [l(vhead, vfinal)]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}\langle \mathrm{dobj} \circ_{<dc}(\mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf}))\rangle^{vfinal}) \vdash s & [p(vfinal, < dc)]\\ \hline
\mathrm{subj} \circ_{<sc}\langle \mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf})))\rangle^{vfinal} \vdash s & [p(vfinal, < sc)]\\ \hline
\langle \mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf}))))\rangle^{vfinal} \vdash s & [p(vfinal, < sc)]\\ \hline
\langle \mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf}))))\rangle^{sub} \vdash s & [Sub\ is\ vfinal]\\ \hline
\mathrm{subj} \circ_{<sc}(\mathrm{subj} \circ_{<sc}(\mathrm{dobj} \circ_{<dc}(\mathrm{perc} \circ_{<per}(\mathrm{modi} \circ_{<mod}\mathrm{inf})))) \vdash \Box^{\downarrow}{}_{sub}s & [\Box^{\downarrow}I]
\end{array}$$

As it turns out, the packages VFinal and XDep take a similar approach to capturing cross-serial dependencies as the model proposed by Moortgat in (1999). ⊛

In the examples in (414) we illustrated a peculiar contrast between Flemish and Dutch, where it concerns the verb final cluster.[12] In (standard) Dutch, the verb final cluster must be *continuous* - we cannot have verbal complements interspersed with the verbs making up the verbal cluster.

Flemish, on the other hand, *does* allow for that, giving rise to the possibility of what we call here *discontinuous crossed ordering.* The ordering among the components making up the verb final cluster is still the same as in Dutch, but we may have that -for example- the **Patient** (direct complement) or an **Addressee** or **Beneficiary** (indirect complement) appears inbetween the auxiliary and the verbal head. The structural rules in the DXDep package extend the VFinal.XDep package to allow for these alternative orderings.

Definition 26 (VFinal, Discontinuous Crossed Ordering (VFinal.XDep.DXDep)). *The DXDep package is an extension of VFinal's XDep package, and covers the construction of discontinuous verb final clusters with a crossed ordering. The DXDep monotonically extends XDep with the rules given in (426) below.*

(426)
$$\begin{array}{lll} \langle A \circ_{<dc} B\rangle^{vhead} \rightarrow A \circ_{<dc} \langle B\rangle^{vhead} & [VFinal.XDep.DXDep1.p(vhead, dc)] \\ \langle A \circ_{<ic} B\rangle^{vhead} \rightarrow A \circ_{<ic} \langle B\rangle^{vhead} & [VFinal.XDep.DXDep.1.p(vhead, ic)] \end{array}$$

⊛

Remark 24 (Explanation of the DXDep package). The DXDep package simply follows out the strategy we developed in the XDep. Namely, the distributional characteristics of the *vhead* and *vfinal* features define those structures to be well-formed that allow for proper distribution of the features over the modal configurations making up these structures. If the *vhead/vfinal* features cannot be distributed over a particular construction, it is ill-formed - at least from the viewpoint of these packages.

The DXDep relaxes the distributional characteristics of the features. The features not only distribute over continuous verb final clusters, as determined by the XDep package - the rules given in (426) allow now for distribution over the *dc* and *ic* modes as well. In conjunction with the structural rules in

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[12] I would like to thank Michael Moortgat for pointing this out to me.

the XDep package this gives rise to the possible formation of discontinuous clusters, as the examples below illustrate.

(427) a. **Flemish**

...(dat) Christopher wil boeken lezen.
Christopher wants books to read.

"...(that) Christopher wants to read books."

b.

$$\begin{array}{c l}
\vdots & \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{dobj} \circ_{<dc} \langle \mathrm{inf} \rangle^{vhead})) \vdash s & [\backslash E] \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} \langle \mathrm{dobj} \circ_{<dc} \mathrm{inf} \rangle^{vhead}) \vdash s & [VFinal.XDep.DXDep1.p(vhead, dc)] \\ \hline
\mathrm{subj} \circ_{<sc} \langle \mathrm{aux} \circ_{<aux} (\mathrm{dobj} \circ_{<dc} \mathrm{inf}) \rangle^{vhead} \vdash s & [VFinal.XDep1.p(vhead, aux)] \\ \hline
\mathrm{subj} \circ_{<sc} \langle \mathrm{aux} \circ_{<aux} (\mathrm{dobj} \circ_{<dc} \mathrm{inf}) \rangle^{vfinal} \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\langle \mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{dobj} \circ_{<dc} \mathrm{inf})) \rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle \mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{dobj} \circ_{<dc} \mathrm{inf})) \rangle^{sub} \vdash s & [Sub\ is\ vfinal] \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{dobj} \circ_{<dc} \mathrm{inf})) \vdash \Box^{\downarrow}{}_{sub} s & [\Box^{\downarrow} I]
\end{array}$$

(428) a. **Flemish**

....(dat) Kathy wil kunnen Sanskrit schrijven.
Kathy wants to be able to Sanskrit to write

"...(that) Kathy wants to be able to write Sanskrit."

b.

$$\begin{array}{c l}
\vdots & \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \langle \mathrm{inf} \rangle^{vhead}))) \vdash s & [\backslash E] \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} \langle \mathrm{dobj} \circ_{<dc} \mathrm{inf} \rangle^{vhead})) \vdash s & [DXDep1.p(vhead, dc)] \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} \langle \mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \mathrm{inf}) \rangle^{vhead}) \vdash s & [XDep1.p(vhead, mod)] \\ \hline
\mathrm{subj} \circ_{<sc} \langle \mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \mathrm{inf})) \rangle^{vhead} \vdash s & [XDep1.p(vhead, aux)] \\ \hline
\mathrm{subj} \circ_{<sc} \langle \mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \mathrm{inf})) \rangle^{vfinal} \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\langle \mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \mathrm{inf}))) \rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle \mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \mathrm{inf}))) \rangle^{sub} \vdash s & [Sub\ is\ vfinal] \\ \hline
\mathrm{subj} \circ_{<sc} (\mathrm{aux} \circ_{<aux} (\mathrm{modi} \circ_{<mod} (\mathrm{dobj} \circ_{<dc} \mathrm{inf}))) \vdash \Box^{\downarrow}{}_{sub} s & [\Box^{\downarrow} I]
\end{array}$$

⊛

Another way in which languages may order the verb final cluster is a nested ordering, leading to *nested dependencies*. Among Germanic languages for example German has a nested ordering. This type of ordering is brought about by placing the verbs making up the cluster *after* the verbal head, rather than before as in the case of a crossed ordering. The examples in (429) below illustrate the contrast between a Dutch crossed ordering and a German nested ordering.

(429) a. **Dutch**

...(dat) Kathy Sanskrit wil kunnen schrijven
Kathy Sanskrit wants to be able to to write

"...(that) Kathy wants to be able to write Sanskrit."

b. **German**

...(daß) Kathy Sanskrit schreiben können will.
Kathy Sanskrit to write to be able to wants

"...(that) Kathy wants to be able to write Sanskrit."

The NDep package extends the VFinal package to cover constructions like (429b).

Definition 27 (Verb Final Clusters, Nested Ordering (VFinal.NDep)). *The NDep package monotonically extends the VFinal package, and models nested ordering. The package consists of the structural rules given in (430).*

(430)

$$\begin{array}{rcll}
B \circ_{<dc} (C \circ_{mod>} A) & \rightarrow & A \circ_{<mod} (B \circ_{<dc} C) & [VFinal.NDep0.m(mod)] \\
B \circ_{<ic} (C \circ_{mod>} A) & \rightarrow & A \circ_{<mod} (B \circ_{<ic} C) & [VFinal.NDep0.m(mod)] \\
B \circ_{<dc} (C \circ_{aux>} A) & \rightarrow & A \circ_{<aux} (B \circ_{<dc} C) & [VFinal.NDep0.m(aux)] \\
B \circ_{<ic} (C \circ_{aux>} A) & \rightarrow & A \circ_{<aux} (B \circ_{<ic} C) & [VFinal.NDep0.m(aux)] \\
B \circ_{<dc} (C \circ_{per>} A) & \rightarrow & A \circ_{<per} (B \circ_{<dc} C) & [VFinal.NDep0.m(per)] \\
B \circ_{<ic} (C \circ_{per>} A) & \rightarrow & A \circ_{<per} (B \circ_{<ic} C) & [VFinal.NDep0.m(per)] \\
\langle A \circ_{aux>} B \rangle^{vhead} & \rightarrow & \langle A \rangle^{vhead} \circ_{aux>} B & [VFinal.NDep1.p(vhead, aux)] \\
\langle A \circ_{mod>} B \rangle^{vhead} & \rightarrow & \langle A \rangle^{vhead} \circ_{mod>} B & [VFinal.NDep1.p(vhead, mod)] \\
\langle A \circ_{per>} B \rangle^{vhead} & \rightarrow & \langle A \rangle^{vhead} \circ_{per>} B & [VFinal.NDep1.p(vhead, per)]
\end{array}$$

⊛

Remark 25 (Explanation of the NDep package). There is little to explain about the NDep package, as it follows exactly the same pattern of thinking as does the XDep package. The only concrete differences here are the placement of the components making up the cluster: rather than being placed before the verbal head, they are placed after it. The rules in NDep are thus, in other words, the mirror image of the structural rules in XDep. The example below, repeating (429b), illustrates the use of the NDep package.

(431) a. **German**

...(daß) Kathy Sanskrit schreiben können will.

b.

$$\begin{array}{c l}
\vdots & [\backslash E] \\ \hline
\text{subj} \circ_{<sc} (\text{aux} \circ_{<aux} (\text{modi} \circ_{<mod} (\text{dobj} \circ_{<dc} \langle \text{inf} \rangle^{vhead}))) \vdash s & [NDep0.m(mod)] \\ \hline
\text{subj} \circ_{<sc} (\text{aux} \circ_{<aux} (\text{dobj} \circ_{<dc} (\langle \text{inf} \rangle^{vhead} \circ {}_{mod>} \text{modi}))) \vdash s & [NDep1.p(vhead, mod)] \\ \hline
\text{subj} \circ_{<sc} (\text{aux} \circ_{<aux} (\text{dobj} \circ_{<dc} \langle \text{inf} \circ {}_{mod>} \text{modi} \rangle^{vhead})) \vdash s & [NDep0.m(aux)] \\ \hline
\text{subj} \circ_{<sc} (\text{dobj} \circ_{<dc} (\langle \text{inf} \circ {}_{mod>} \text{modi} \rangle^{vhead} \circ {}_{aux>} \text{aux})) \vdash s & [NDep1.p(vhead, aux)] \\ \hline
\text{subj} \circ_{<sc} (\text{dobj} \circ_{<dc} \langle (\text{inf} \circ {}_{mod>} \text{modi}) \circ {}_{aux>} \text{aux} \rangle^{vhead}) \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\text{subj} \circ_{<sc} (\text{dobj} \circ_{<dc} \langle (\text{inf} \circ {}_{mod>} \text{modi}) \circ {}_{aux>} \text{aux} \rangle^{vfinal}) \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\text{subj} \circ_{<sc} \langle \text{dobj} \circ_{<dc} ((\text{inf} \circ {}_{mod>} \text{modi}) \circ {}_{aux>} \text{aux}) \rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle \text{subj} \circ_{<sc} (\text{dobj} \circ_{<dc} ((\text{inf} \circ {}_{mod>} \text{modi}) \circ {}_{aux>} \text{aux})) \rangle^{vfinal} \vdash s & [Sub\ is\ vfinal] \\ \hline
\langle \text{subj} \circ_{<sc} (\text{dobj} \circ_{<dc} ((\text{inf} \circ {}_{mod>} \text{modi}) \circ {}_{aux>} \text{aux})) \rangle^{sub} \vdash s & [\Box^{\downarrow} I] \\ \hline
\text{subj} \circ_{<sc} (\text{dobj} \circ_{<dc} ((\text{inf} \circ {}_{mod>} \text{modi}) \circ {}_{aux>} \text{aux})) \vdash \Box^{\downarrow}{}_{sub} s &
\end{array}$$

⊛

Example (Dutch, Flemish, and German subordinate clauses). In the definitions we gave above we stressed the fact that packages provide *monotonic extensions*. They thus act as building blocks - fragments that we can use to build grammars to cover a language. Moreover, because of a modularity that models aspects that languages may have in common, we can easily build *multilingual* fragments (cf. Chapter 4). Using Dutch, Flemish and German examples we already illustrated how the VFinal, XDep, DXDep and NDep packages work. Taken together, we can create a multilingual fragment for Dutch (D), Flemish (F) and German (G) subordinate clause word order, as shown in Figure 7.3.

[VFinal0.*]$_{\{D,F,G\}}$ [VFinal1.*]$_{\{D,F,G\}}$ [VFinal.XDep0.*]$_{\{D,F\}}$ [VFinal.XDep1
]$_{\{D,F\}}$ [VFinal.XDep.DXDep0.*]$_{\{F\}}$ [VFinal.XDep.DXDep1.*]$_{\{F\}}$
[VFinal.NDep0.*]$_{\{G\}}$ [VFinal.NDep1.*]$_{\{G\}}$

Figure 7.3: A multilingual network for subordinate clause WO in Dutch, Flemish and German

There are -naturally- more packages for modeling OV behavior, as we saw in Figure 7.1 on page 236. Below we define the NrOV package that defines nonrigid verb finality, which is based on the MxOV package that defines scrambling or mixed word order in OV languages. Finally, we define the FreeOV package (also extending MxOV) that allows for free word order in OV languages, like Turkish (Hoffman, 1995a).

Definition 28 (Mixed OV ordering (VFinal.MxOV)). *The MxOV package defines mixed word order for OV languages. For the basic verb fi-*

nal control mechanisms, MxOV makes use of VFinal (which it thus extends). MxOV comprises the structural rules given in (432).

(432)
$$\begin{array}{rcll}
\langle B\rangle^{dat}\circ_{<ic}\langle\langle A\rangle^{acc}\circ_{<dc}C\rangle^{vfinal} & \rightarrow & \langle A\rangle^{acc}\circ_{<dc}\langle\langle B\rangle^{dat}\circ_{<ic}C\rangle^{vfinal} & [MxOV0.m(dc,ic)]\\
\langle B\rangle^{dat}\circ_{<ic}\langle\langle A\rangle^{nom}\circ_{<sc}C\rangle^{vfinal} & \rightarrow & \langle A\rangle^{nom}\circ_{<sc}\langle\langle B\rangle^{dat}\circ_{<ic}C\rangle^{vfinal} & [MxOV0.m(sc,ic)]\\
\langle\langle B\rangle^{dat}\circ_{<ic}(\langle A\rangle^{acc}\circ_{<dc}C)\rangle^{vfinal} & \rightarrow & \langle\langle A\rangle^{acc}\circ_{<dc}(\langle B\rangle^{dat}\circ_{<ic}C)\rangle^{vfinal} & [MxOV0.m(dc,ic)]\\
\langle\langle B\rangle^{acc}\circ_{<dc}(\langle A\rangle^{nom}\circ_{<sc}C)\rangle^{vfinal} & \rightarrow & \langle\langle A\rangle^{nom}\circ_{<sc}(\langle B\rangle^{acc}\circ_{<dc}C)\rangle^{vfinal} & [MxOV0.m(sc,dc)]\\
\langle\langle B\rangle^{dat}\circ_{<ic}(\langle A\rangle^{nom}\circ_{<sc}C)\rangle^{vfinal} & \rightarrow & \langle\langle A\rangle^{nom}\circ_{<sc}(\langle B\rangle^{dat}\circ_{<ic}C)\rangle^{vfinal} & [MxOV0.m(sc,ic)]\\
\langle B\rangle^{acc}\circ_{<dc}\langle\langle A\rangle^{nom}\circ_{<sc}C\rangle^{vfinal} & \rightarrow & \langle A\rangle^{nom}\circ_{<sc}\langle\langle B\rangle^{acc}\circ_{<dc}C\rangle^{vfinal} & [MxOV0.m(sc,dc)]
\end{array}$$

⊛

Remark 26 (Explanation of the MxOV package). The structural rules in (450) obey the verb final character of the clause in a similar way like Set-CCG. The directionality remains fixed, in that the rightmost element (where the verbal head is located) is never moved. Moreover, conform VFinal, we define the eligible orders in terms of a distribution of the *vfinal* feature. Finally, we make the possibility to scramble dependent on the presence of case-marking. The reason for doing so is that languages generally tend to rigidify their word order as soon as case-marking (inflection) is absent, or case is realized through function words. We can observe this for example in German subordinate clauses, where scrambling of complements is only possible if they are properly marked for case, and in Turkish, where word order becomes SOV as soon as case marking is suppressed (cf. (Hoffman, 1995a),p.50ff).

To illustrate the MxOV package, consider the following Japanese examples, adapted from Tsujimura's (1996)(p.186). The sentence in (433) gives the canonical ordering of the elements, whereas the sentences in give the other possible orderings.

(433) **Japanese**

Kinoo Taroo-ga susi-o tabeta.
yesterday Taro-NOM sushi-ACC eat-PAST

"Taroo ate susi yesterday."

(434) a. Taroo-ga kinoo susi-o tabeta.

b. Taroo-ga susi-o kinoo tabeta.

c. Susi-o Taroo-ga kinoo tabeta.

d. Susi-o kinoo Taroo-ga tabeta.

e. Kinoo susi-o Taroo-ga tabeta.

All these orders are derivable using MxOV and the following structural rules that add behavior for the mode *tma* (temporal adjunct).

(435)
$$\begin{array}{rcll}
\langle B\rangle^{nom} \circ_{<sc} \langle A \circ_{<tma} C\rangle^{\mathit{vfinal}} & \rightarrow & A \circ_{<tma} \langle\langle B\rangle^{nom} \circ_{<sc} C\rangle^{\mathit{vfinal}} & [MxOV0.m(tma, sc)] \\
\langle\langle B\rangle^{acc} \circ_{<dc} (A \circ_{<tma} C)\rangle^{\mathit{vfinal}} & \rightarrow & \langle A \circ_{<tma} (\langle B\rangle^{acc} \circ_{<dc} C)\rangle^{\mathit{vfinal}} & [MxOV0.m(tma, dc)] \\
\langle A \circ_{<tma} B\rangle^{\mathit{vfinal}} & \rightarrow & A \circ_{<tma} \langle B\rangle^{\mathit{vfinal}} & [VFinal1.p(vfinal, < tma
\end{array}$$

(436) a.
$$\begin{array}{cl}
\vdots & \\ \hline
\text{temp} \circ_{<tma} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \langle\text{tverb}\rangle^{\mathit{vfinal}})) \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\text{temp} \circ_{<tma} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb}\rangle^{\mathit{vfinal}}) \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\text{temp} \circ_{<tma} \langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\text{temp} \circ_{<tma} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [MxOV0.m(tma, sc)] \\ \hline
\langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\text{temp} \circ_{<tma} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb}))\rangle^{\mathit{vfinal}} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\text{temp} \circ_{<tma} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb}))\rangle^{mtx} \vdash s & [Matrix\ is\ vfinal] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\text{temp} \circ_{<tma} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})) \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

b.
$$\begin{array}{cl}
\vdots & \\ \hline
\text{temp} \circ_{<tma} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \langle\text{tverb}\rangle^{\mathit{vfinal}})) \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\text{temp} \circ_{<tma} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb}\rangle^{\mathit{vfinal}}) \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\text{temp} \circ_{<tma} \langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\text{temp} \circ_{<tma} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [MxOV0.m(tma, sc)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\text{temp} \circ_{<tma} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [MxOV0.m(tma, dc)] \\ \hline
\langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\text{temp} \circ_{<tma} \text{tverb}))\rangle^{\mathit{vfinal}} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\text{temp} \circ_{<tma} \text{tverb}))\rangle^{mtx} \vdash s & [Matrix\ is\ vfinal] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\text{temp} \circ_{<tma} \text{tverb})) \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

c.
$$\begin{array}{cl}
\vdots & \\ \hline
\text{temp} \circ_{<tma} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \langle\text{tverb}\rangle^{\mathit{vfinal}})) \vdash s & [VFinal0.l(vhead, vfinal \\ \hline
\text{temp} \circ_{<tma} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb}\rangle^{\mathit{vfinal}}) \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\text{temp} \circ_{<tma} \langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\text{temp} \circ_{<tma} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [MxOV0.m(tma, sc)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc} \langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\text{temp} \circ_{<tma} \text{tverb})\rangle^{\mathit{vfinal}} \vdash s & [MxOV0.m(tma, dc)] \\ \hline
\langle\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\text{temp} \circ_{<tma} \text{tverb}))\rangle^{\mathit{vfinal}} \vdash s & [VFinal1.p(vfinal, < sc)] \\ \hline
\langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\text{temp} \circ_{<tma} \text{tverb}))\rangle^{\mathit{vfinal}} \vdash s & [MxOV0.m(sc, dc)] \\ \hline
\langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\text{temp} \circ_{<tma} \text{tverb}))\rangle^{mtx} \vdash s & [Matrix\ is\ vfinal] \\ \hline
\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\langle\text{subjc}\rangle^{nom} \circ_{<sc} (\text{temp} \circ_{<tma} \text{tverb})) \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

⊛

Whereas some OV languages have mixed word order but are otherwise rigidly verb final, like Japanese or Korean, other OV languages do allow for single dependents (of the matrix verb) to occur *after* the verbal head. For example, Herring & Paolillo discuss Sinhala, an Indo-Aryan language that is SOV (Greenberg/Hawkins type 23) and which is non-rigid in the this way. Consider the examples in (437) and (438), from (Herring and Paolillo, 1995)(pp.169-170).

(437) **Sinhala**

oya	gan̆-en	e-goḍa	eka	paetta-k-a	loku	kaelaeaewa-k
that	rivier-INSTR	that-bank	one	side-INDEF-LOC	large	forest-INDEF

tibunaa.
be-PAST.

"On the far bank of that rivier was a large forest."

(438) a. **Sinhala**

gan̆-en	me-goḍa-t	tibunaa	kaelaeaewa-k.
river-INSTR	this-bank-also	be-PAST	forest-INDEF

"On this bank of the rivier also was a forest."

b. **Sinhala**

oya	kaelaeaewa-we	hiṭiyaa	nariy-ek.
that	forest-LOC	live-PAST	jackal-INDEF

"In that forest lived a jackal."

Herring & Paolillo associate the post-verbal positioning of a dependent with (presentational) focus, bringing to the fore the introduction of new information.Later we come back to this use of post-verbal positioning - for the moment, we are just concerned with the pure form of the construction.

Definition 29 (Nonrigid OV ordering (VFinal.MxOV.NrOV)). *The NrOV package extends the VFinal and MxOV packages, modeling nonrigid verb finality. Following out the strategy introduced in VFinal, we have a feature that controls the postverbal positioning, called* nrvfinal. *The feature interacts with* vfinal *and ensures that only a single dependent can be placed postverbally. NrOV consists of the structural rules in (439).*

(439)
$$\begin{array}{rcll}
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{nrvfinal} & [Matrix\ is\ nonrigid - vfinal] \\
\langle B \circ_{sc>} A\rangle^{nrvfinal} & \rightarrow & A \circ_{<sc} \langle B\rangle^{vfinal} & [NrOV0.m(sc)] \\
\langle B \circ_{ic>} A\rangle^{nrvfinal} & \rightarrow & A \circ_{<ic} \langle B\rangle^{vfinal} & [NrOV0.m(ic)] \\
\langle B \circ_{dc>} A\rangle^{nrvfinal} & \rightarrow & A \circ_{<dc} \langle B\rangle^{vfinal} & [NrOV0.m(dc)]
\end{array}$$

⊛

Remark 27 (Explanation of the NrOV package). As we point out in the definition, the package introduces a new feature, *nrvfinal*, that controls postverbal positioning. By means of a linking rule, we can have that a matrix (*mtx*) clause has a postverbal dependent. That is the case if and only if a single dependent is placed *after* construction that is otherwise verb final.

The derivations in (440) examplify the structural rules of NrOV, on (abstract) clauses similar in form to the examples in (438). Observe that, because we still have the link between *mtx* and $vfinal$ as well (from VFinal) examples like (438) already follow from VFinal+MxOV.

(440) a.

$$\dfrac{\dfrac{\text{subjc} \vdash \Box^{\downarrow}{}_{nom}\Box^{\downarrow}{}_{act}n}{\langle\text{subjc}\rangle^{nom} \vdash \Box^{\downarrow}{}_{act}n}[\Box^{\downarrow}E] \quad \dfrac{\dfrac{\text{dobjc} \vdash \Box^{\downarrow}{}_{acc}\Box^{\downarrow}{}_{pat}n}{\langle\text{dobjc}\rangle^{acc} \vdash \Box^{\downarrow}{}_{pat}n}[\Box^{\downarrow}E] \quad \dfrac{\vdots}{\langle\text{iobjc}\rangle^{dat} \circ_{<ic} \langle\text{dtverb}\rangle^{vhead} \vdash \Box^{\downarrow}{}_{pat}n\backslash_{<dc}(\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)}[\backslash E]}{\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic} \langle\text{dtverb}\rangle^{vhead}) \vdash \Box^{\downarrow}{}_{act}n\backslash_{<sc}s}[\backslash E]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic} \langle\text{dtverb}\rangle^{vhead})) \vdash s}[\backslash E]$$

$$\begin{array}{cl}
\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic} \langle\text{dtverb}\rangle^{vhead})) \vdash s & \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic} \langle\text{dtverb}\rangle^{vfinal})) \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}\rangle^{vfinal}) \vdash s & [VFinal1.p(vfinal, < ic)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc}\langle(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})\rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle(\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})\rangle^{vfinal} \vdash s & [MxOV0.m(sc, dc)] \\ \hline
\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}(\langle\text{subjc}\rangle^{nom} \circ_{<sc}\text{dtverb})\rangle^{vfinal} \vdash s & [MxOV0.m(sc, ic)] \\ \hline
\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\langle(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{subjc}\rangle^{nom} \circ_{<sc}\text{dtverb})\rangle^{vfinal} \vdash s & [MxOV0.m(dc, ic)] \\ \hline
\langle((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{subjc}\rangle^{nom} \circ_{<sc}\text{dtverb})) \circ_{ic>} \langle\text{iobjc}\rangle^{dat}\rangle^{nrvfinal} \vdash s & [NrOV0.m(ic)] \\ \hline
\langle((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{subjc}\rangle^{nom} \circ_{<sc}\text{dtverb})) \circ_{ic>} \langle\text{iobjc}\rangle^{dat}\rangle^{mtx} \vdash s & [Matrix\ is\ nonrigid - vfinal] \\ \hline
((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{subjc}\rangle^{nom} \circ_{<sc}\text{dtverb})) \circ_{ic>} \langle\text{iobjc}\rangle^{dat} \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

b.

$$\begin{array}{cl}
\vdots & \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic} \langle\text{dtverb}\rangle^{vfinal})) \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}\rangle^{vfinal}) \vdash s & [VFinal1.p(vfinal, < ic)] \\ \hline
\langle\text{subjc}\rangle^{nom} \circ_{<sc}\langle(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})\rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle(\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})\rangle^{vfinal} \vdash s & [MxOV0.m(sc, dc)] \\ \hline
\langle((\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{nrvfinal} \vdash s & [NrOV0.m(dc)] \\ \hline
\langle((\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{mtx} \vdash s & [Matrix\ is\ nonrigid - vfina \\ \hline
((\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

c.

$$\begin{array}{cl}
\vdots & \\ \hline
\langle \text{subjc}\rangle^{nom} \circ_{<sc}(\langle \text{dobjc}\rangle^{acc} \circ_{<dc}(\langle \text{iobjc}\rangle^{dat} \circ_{<ic}\langle \text{dtverb}\rangle^{vfinal})) \vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\langle \text{subjc}\rangle^{nom} \circ_{<sc}(\langle \text{dobjc}\rangle^{acc} \circ_{<dc}\langle(\langle \text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}\rangle^{vfinal}) \vdash s & [VFinal1.p(vfinal, < ic)] \\ \hline
\langle \text{subjc}\rangle^{nom} \circ_{<sc}\langle(\langle \text{dobjc}\rangle^{acc} \circ_{<dc}(\langle \text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}))\rangle^{vfinal} \vdash s & [VFinal1.p(vfinal, < dc)] \\ \hline
\langle((\langle \text{dobjc}\rangle^{acc} \circ_{<dc}(\langle \text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle \text{subjc}\rangle^{nom}\rangle^{nrvfinal} \vdash s & [NrOV0.m(sc)] \\ \hline
\langle((\langle \text{dobjc}\rangle^{acc} \circ_{<dc}(\langle \text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle \text{subjc}\rangle^{nom}\rangle^{mtx} \vdash s & [Matrix\ is\ nonrigid - vfinal] \\ \hline
((\langle \text{dobjc}\rangle^{acc} \circ_{<dc}(\langle \text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle \text{subjc}\rangle^{nom} \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

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Definition 30 (Free word order from OV (VFinal.MxOV.FreeOV)). *The FreeOV package extends the behavior to free word order of verbal complements, starting from a basic OV order. The FreeOV package consists of the structural rules given in (441). The monotonically extend VFinal and MxOV, and can for example be used in conjunction with NrOV.*

(441)

$$\begin{array}{rcll}
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{free} & [Matrix\ is\ free] \\
\langle A\rangle^{free} & \rightarrow & \langle A\rangle^{vfinal} & [FreeOV0.l(free, vfinal)] \\
\langle A\rangle^{free} & \rightarrow & \langle A\rangle^{nrvfinal} & [FreeOV0.l(free, nrvfinal)] \\
\langle B \circ_{sc>}\langle A\rangle^{nom}\rangle^{free} & \rightarrow & \langle\langle A\rangle^{nom} \circ_{<sc}B\rangle^{free} & [FreeOV1.m(sc)] \\
\langle(B \circ_{sc>}C) \circ_{dc>}\langle A\rangle^{acc}\rangle^{free} & \rightarrow & \langle((\langle A\rangle^{acc} \circ_{<dc}B) \circ_{sc>}C\rangle^{free} & [FreeOV1.m(dc, sc)] \\
\langle(B \circ_{dc>}C) \circ_{ic>}\langle A\rangle^{dat}\rangle^{free} & \rightarrow & \langle((\langle A\rangle^{dat} \circ_{<ic}B) \circ_{dc>}C\rangle^{free} & [FreeOV1.m(ic, dc)] \\
A \circ_{<ic}(B \circ_{sc>}C) & \rightarrow & (A \circ_{<ic}B) \circ_{sc>}C & [FreeOV2.assc(sc, dc)] \\
\langle(A \circ_{ic>}\langle C\rangle^{dat}) \circ_{dc>}\langle B\rangle^{acc}\rangle^{free} & \rightarrow & \langle(A \circ_{dc>}\langle B\rangle^{acc}) \circ_{ic>}\langle C\rangle^{dat}\rangle^{free} & [FreeOV3.m(ic, dc)] \\
\langle(A \circ_{ic>}\langle C\rangle^{dat}) \circ_{sc>}\langle B\rangle^{nom}\rangle^{free} & \rightarrow & \langle(A \circ_{sc>}\langle B\rangle^{nom}) \circ_{ic>}\langle C\rangle^{dat}\rangle^{free} & [FreeOV3.m(ic, sc)] \\
\langle(A \circ_{dc>}\langle C\rangle^{acc}) \circ_{sc>}\langle B\rangle^{nom}\rangle^{free} & \rightarrow & \langle(A \circ_{sc>}\langle B\rangle^{nom}) \circ_{dc>}\langle C\rangle^{acc}\rangle^{free} & [FreeOV3.m(dc, sc)] \\
\langle(A \circ_{ic>}\langle B\rangle^{dat}) \circ_{sc>}\langle C\rangle^{nom}\rangle^{free} & \rightarrow & \langle(A \circ_{sc>}\langle C\rangle^{nom}) \circ_{ic>}\langle B\rangle^{dat}\rangle^{free} & [FreeOV3.m(ic, sc)] \\
\langle(A \circ_{dc>}\langle B\rangle^{acc}) \circ_{sc>}\langle C\rangle^{nom}\rangle^{free} & \rightarrow & \langle(A \circ_{sc>}\langle C\rangle^{nom}) \circ_{dc>}\langle B\rangle^{acc}\rangle^{free} & [FreeOV3.m(dc, sc)] \\
\langle A\rangle^{free} \circ_{ic>}B & \rightarrow & \langle A \circ_{ic>}B\rangle^{free} & [FreeOV4.p(free, ic)] \\
\langle A \circ_{ic>}B\rangle^{free} & \rightarrow & \langle A\rangle^{free} \circ_{ic>}B & [FreeOV4.p(free, ic)] \\
\langle A\rangle^{free} \circ_{dc>}B & \rightarrow & \langle A \circ_{dc>}B\rangle^{free} & [FreeOV4.p(free, dc)] \\
\langle A \circ_{dc>}B\rangle^{free} & \rightarrow & \langle A\rangle^{free} \circ_{dc>}B & [FreeOV4.p(free, dc)] \\
\langle A\rangle^{free} \circ_{sc>}B & \rightarrow & \langle A \circ_{sc>}B\rangle^{free} & [FreeOV4.p(free, sc)] \\
\langle A \circ_{sc>}B\rangle^{free} & \rightarrow & \langle A\rangle^{free} \circ_{sc>}B & [FreeOV4.p(free, sc)]
\end{array}$$

Remark 28 (Explanation of the FreeOV package). The FreeOV package builds forth on the MxOV package by letting the latter handle all the scrambling that maintains verb finality. FreeOV adds to that behavior by first of all enabling the formation of an VO order, using the FreeOV1.* and FreeOV2.* rules.[13] Just like MxOV, we define structural rules that allow for

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[13] Thus, in a sense FreeOV takes further the behavior we define in NrOV.

scrambling of the arguments at any level of the tree, as long as the entire structure is marked as *free*. The FreeOV3.* are responsible for that. The FreeOV4.* make sure that we can freely reorder elements at the top-most level of the tree as well as more embedded levels. The example derivations in (442) illustrate FreeOV on the abstract lexicon with case marking.

(442) a.

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{subjc} \vdash \Box^{\downarrow}{}_{nom}\Box^{\downarrow}{}_{act}n}{\langle\text{subjc}\rangle^{nom} \vdash \Box^{\downarrow}{}_{act}n}\;[\Box^{\downarrow}E] \qquad \dfrac{\vdots}{\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\langle\text{dtverb}\rangle^{vhead}) \vdash \Box^{\downarrow}{}_{act}n\backslash_{<sc}s}\;[\backslash E]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\langle\text{dtverb}\rangle^{vhead})) \vdash s}\;[\backslash E]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\langle\text{dtverb}\rangle^{vfinal})) \vdash s}\;[VFinal0.l(vhead, vfinal)]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}\rangle^{vfinal}) \vdash s}\;[VFinal1.p(vfinal, < ic)]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}\langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})\rangle^{vfinal} \vdash s}\;[VFinal1.p(vfinal, < dc)]}{\langle((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{nrvfinal} \vdash s}\;[NrOV0.m(sc)]}{\langle((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{free} \vdash s}\;[FreeOV0.l(free, nrvfinal)]}{\langle(((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{free} \vdash s}\;[FreeOV1.m(dc, sc)]}{\langle(((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{free} \vdash s}\;[FreeOV3.m(dc, sc)]}{\langle(((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{mtx} \vdash s}\;[Matrix\ is\ free]}{(((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom} \vdash \Box^{\downarrow}{}_{mtx}s}\;[\Box^{\downarrow}I]$$

b.

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\vdots}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\langle\text{dtverb}\rangle^{vfinal})) \vdash s}\;[VFinal0.l(vhead, vfinal)]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}(\langle\text{dobjc}\rangle^{acc} \circ_{<dc}\langle\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}\rangle^{vfinal}) \vdash s}\;[VFinal1.p(vfinal, < ic)]}{\langle\text{subjc}\rangle^{nom} \circ_{<sc}\langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})\rangle^{vfinal} \vdash s}\;[VFinal1.p(vfinal, < dc)]}{\langle((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{nrvfinal} \vdash s}\;[NrOV0.m(sc)]}{\langle((\langle\text{dobjc}\rangle^{acc} \circ_{<dc}(\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb})) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{free} \vdash s}\;[FreeOV0.l(free, nrvfinal)]}{\langle(((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{free} \vdash s}\;[FreeOV1.m(dc, sc)]}{\langle(((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{free} \vdash s}\;[FreeOV3.m(dc, sc)]}{\langle((\langle\text{iobjc}\rangle^{dat} \circ_{<ic}\text{dtverb}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{free} \circ_{sc>}\langle\text{subjc}\rangle^{nom} \vdash s}\;[FreeOV4.p(free, sc)]}{\langle((\text{dtverb} \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{ic>}\langle\text{iobjc}\rangle^{dat}\rangle^{free} \circ_{sc>}\langle\text{subjc}\rangle^{nom} \vdash s}\;[FreeOV1.m(ic, dc)]}{\langle((\text{dtverb} \circ_{ic>}\langle\text{iobjc}\rangle^{dat}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{free} \circ_{sc>}\langle\text{subjc}\rangle^{nom} \vdash s}\;[FreeOV3.m(ic, dc)]}{\langle(((\text{dtverb} \circ_{ic>}\langle\text{iobjc}\rangle^{dat}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{free} \vdash s}\;[FreeOV4.p(free, sc)]}{\langle(((\text{dtverb} \circ_{ic>}\langle\text{iobjc}\rangle^{dat}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom}\rangle^{mtx} \vdash s}\;[Matrix\ is\ free]}{((\text{dtverb} \circ_{ic>}\langle\text{iobjc}\rangle^{dat}) \circ_{dc>}\langle\text{dobjc}\rangle^{acc}) \circ_{sc>}\langle\text{subjc}\rangle^{nom} \vdash \Box^{\downarrow}{}_{mtx}s}\;[\Box^{\downarrow}I]$$

c.

$$\begin{array}{cl}
\vdots & \\ \hline
\langle\text{subjc}\rangle^{nom}\circ_{<sc}(\langle\text{dobjc}\rangle^{acc}\circ_{<dc}(\langle\text{iobjc}\rangle^{dat}\circ_{<ic}\langle\text{dtverb}\rangle^{\mathit{vfinal}}))\vdash s & [VFinal0.l(vhead, vfinal)] \\ \hline
\langle\text{subjc}\rangle^{nom}\circ_{<sc}(\langle\text{dobjc}\rangle^{acc}\circ_{<dc}\langle\langle\text{iobjc}\rangle^{dat}\circ_{<ic}\text{dtverb}\rangle^{\mathit{vfinal}})\vdash s & [VFinal1.p(vfinal, <ic)] \\ \hline
\langle\text{subjc}\rangle^{nom}\circ_{<sc}\langle\langle\text{dobjc}\rangle^{acc}\circ_{<dc}(\langle\text{iobjc}\rangle^{dat}\circ_{<ic}\text{dtverb})\rangle^{\mathit{vfinal}}\vdash s & [VFinal1.p(vfinal, <dc)] \\ \hline
\langle\text{dobjc}\rangle^{acc}\circ_{<dc}\langle\langle\text{subjc}\rangle^{nom}\circ_{<sc}(\langle\text{iobjc}\rangle^{dat}\circ_{<ic}\text{dtverb})\rangle^{\mathit{vfinal}}\vdash s & [MxOV0.m(sc, dc)] \\ \hline
\langle\text{dobjc}\rangle^{acc}\circ_{<dc}\langle\langle\text{iobjc}\rangle^{dat}\circ_{<ic}(\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb})\rangle^{\mathit{vfinal}}\vdash s & [MxOV0.m(sc, ic)] \\ \hline
\langle((\langle\text{iobjc}\rangle^{dat}\circ_{<ic}(\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb}))\circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{\mathit{nrvfinal}}\vdash s & [NrOV0.m(dc)] \\ \hline
\langle((\langle\text{iobjc}\rangle^{dat}\circ_{<ic}(\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb}))\circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{\mathit{free}}\vdash s & [FreeOV0.l(free, nrvfinal)] \\ \hline
\langle(((\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb})\circ_{dc>}\langle\text{dobjc}\rangle^{acc})\circ_{ic>}\langle\text{iobjc}\rangle^{dat}\rangle^{\mathit{free}}\vdash s & [FreeOV1.m(ic, dc)] \\ \hline
\langle(((\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb})\circ_{ic>}\langle\text{iobjc}\rangle^{dat})\circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{\mathit{free}}\vdash s & [FreeOV3.m(ic, dc)] \\ \hline
\langle(((\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb})\circ_{ic>}\langle\text{iobjc}\rangle^{dat})\circ_{dc>}\langle\text{dobjc}\rangle^{acc}\rangle^{mtx}\vdash s & [Matrix\ is\ free] \\ \hline
((\langle\text{subjc}\rangle^{nom}\circ_{<sc}\text{dtverb})\circ_{ic>}\langle\text{iobjc}\rangle^{dat})\circ_{dc>}\langle\text{dobjc}\rangle^{acc}\vdash\Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

⊛

Observe that in FreeOV we maintain the requirement that dependents need to have explicit case marking for them to be able to scramble. Naturally, we can easily relax this constraint - structure of the rules remains the same, only we no longer *need* to have any feature marking on A, B or C. The definition below gives the relaxed definitions of MxOV (MxOVnc) and FreeOV (FreeOVnc). The packages MxOVnc and FreeOVnc monotonically extend one another, as well as the MxOV and FreeOV packages, and can for example be used to model the free word order of Hindi.

Definition 31 (Mixed/free OV word order without case marking). *The MxOVnc package is a relaxed version of MxOV, in which dependents no longer need to be explicitly marked for case. MxOVnc comprises the rules given in (443). FreeOVnc is a similarly relaxed version of FreeOV, consisting of the rules given in (444).*

(443)

$$\begin{array}{rcll}
B\circ_{<ic}\langle A\circ_{<dc}C\rangle^{\mathit{vfinal}} & \rightarrow & A\circ_{<dc}\langle B\circ_{<ic}C\rangle^{\mathit{vfinal}} & [MxOVnc0.m(dc, ic)] \\
B\circ_{<ic}\langle A\circ_{<sc}C\rangle^{\mathit{vfinal}} & \rightarrow & A\circ_{<sc}\langle B\circ_{<ic}C\rangle^{\mathit{vfinal}} & [MxOVnc0.m(sc, ic)] \\
\langle B\circ_{<ic}(A\circ_{<dc}C)\rangle^{\mathit{vfinal}} & \rightarrow & \langle A\circ_{<dc}(B\circ_{<ic}C)\rangle^{\mathit{vfinal}} & [MxOVnc0.m(dc, ic)] \\
\langle B\circ_{<dc}(A\circ_{<sc}C)\rangle^{\mathit{vfinal}} & \rightarrow & \langle A\circ_{<sc}(B\circ_{<dc}C)\rangle^{\mathit{vfinal}} & [MxOVnc0.m(sc, dc)] \\
\langle B\circ_{<ic}(A\circ_{<sc}C)\rangle^{\mathit{vfinal}} & \rightarrow & \langle A\circ_{<sc}(B\circ_{<ic}C)\rangle^{\mathit{vfinal}} & [MxOVnc0.m(sc, ic)] \\
B\circ_{<dc}\langle A\circ_{<sc}C\rangle^{\mathit{vfinal}} & \rightarrow & A\circ_{<sc}\langle B\circ_{<dc}C\rangle^{\mathit{vfinal}} & [MxOVnc0.m(sc, dc)] \\
B\circ_{<sc}\langle A\circ_{<tma}C\rangle^{\mathit{vfinal}} & \rightarrow & A\circ_{<tma}\langle B\circ_{<sc}C\rangle^{\mathit{vfinal}} & [MxOVnc0.m(tma, sc)] \\
\langle B\circ_{<dc}(A\circ_{<tma}C)\rangle^{\mathit{vfinal}} & \rightarrow & \langle A\circ_{<tma}(B\circ_{<dc}C)\rangle^{\mathit{vfinal}} & [MxOVnc0.m(tma, dc)]
\end{array}$$

(444)

$$\begin{array}{rcll}
\langle B \circ_{sc>} A\rangle^{free} & \rightarrow & \langle A \circ_{<sc} B\rangle^{free} & [FreeOV1nc.m(sc)] \\
\langle (B \circ_{sc>} C) \circ_{dc>} A\rangle^{free} & \rightarrow & \langle (A \circ_{<dc} B) \circ_{sc>} C\rangle^{free} & [FreeOV1nc.m(dc,sc)] \\
\langle (B \circ_{dc>} C) \circ_{ic>} A\rangle^{free} & \rightarrow & \langle (A \circ_{<ic} B) \circ_{dc>} C\rangle^{free} & [FreeOV1nc.m(ic,dc)] \\
A \circ_{<ic} (B \circ_{sc>} C) & \rightarrow & (A \circ_{<ic} B) \circ_{sc>} C & [FreeOV2nc.assc(sc,dc)] \\
\langle (A \circ_{ic>} C) \circ_{dc>} B\rangle^{free} & \rightarrow & \langle (A \circ_{dc>} B) \circ_{ic>} C\rangle^{free} & [FreeOV3nc.m(ic,dc)] \\
\langle (A \circ_{ic>} C) \circ_{sc>} B\rangle^{free} & \rightarrow & \langle (A \circ_{sc>} B) \circ_{ic>} C\rangle^{free} & [FreeOV3nc.m(ic,sc)] \\
\langle (A \circ_{dc>} C) \circ_{sc>} B\rangle^{free} & \rightarrow & \langle (A \circ_{sc>} B) \circ_{dc>} C\rangle^{free} & [FreeOV3nc.m(dc,sc)] \\
\langle (A \circ_{ic>} C) \circ_{sc>} B\rangle^{free} & \rightarrow & \langle (A \circ_{sc>} B) \circ_{ic>} C\rangle^{free} & [FreeOV3nc.m(ic,sc)] \\
\langle (A \circ_{dc>} C) \circ_{sc>} B\rangle^{free} & \rightarrow & \langle (A \circ_{sc>} B) \circ_{dc>} C\rangle^{free} & [FreeOV3nc.m(dc,sc)] \\
\langle A\rangle^{free} \circ_{ic>} B & \rightarrow & \langle A \circ_{ic>} B\rangle^{free} & [FreeOV4nc.p(free,ic)] \\
\langle A \circ_{ic>} B\rangle^{free} & \rightarrow & \langle A\rangle^{free} \circ_{ic>} B & [FreeOV4nc.p(free,ic)] \\
\langle A\rangle^{free} \circ_{dc>} B & \rightarrow & \langle A \circ_{dc>} B\rangle^{free} & [FreeOV4nc.p(free,dc)] \\
\langle A \circ_{dc>} B\rangle^{free} & \rightarrow & \langle A\rangle^{free} \circ_{dc>} B & [FreeOV4nc.p(free,dc)] \\
\langle A\rangle^{free} \circ_{sc>} B & \rightarrow & \langle A \circ_{sc>} B\rangle^{free} & [FreeOV4nc.p(free,sc)] \\
\langle A \circ_{sc>} B\rangle^{free} & \rightarrow & \langle A\rangle^{free} \circ_{sc>} B & [FreeOV4nc.p(free,sc)]
\end{array}$$

⊛

7.3.3 V-First packages

After having defined packages dealing with OV word order in the previous section, we now turn our attention to the "mirror" case of VO word order. The reason for dealing first with OV and VO before addressing issues in SVO is that the latter may be conceived of as a mixture of the former two.

The canonical structure for VSO is as given in (445a), with a sample derivation (with goal S) in (445b).

(445) a. $(((Verb \circ_{sc\succ} Subj) \circ_{dc\succ} DObj) \circ_{ic\succ} IObj)$

b.

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{tverb} \vdash \Box^{\downarrow}_{vhead}((s/_{dc>}\Box^{\downarrow}_{pat}n)/_{sc>}\Box^{\downarrow}_{act}n)}{\langle\text{tverb}\rangle^{vhead} \vdash (s/_{dc>}\Box^{\downarrow}_{pat}n)/_{sc>}\Box^{\downarrow}_{act}n}[\Box^{\downarrow}E] \quad \dfrac{\text{subje} \vdash \Box^{\downarrow}_{erg}\Box^{\downarrow}_{act}n}{\langle\text{subje}\rangle^{erg} \vdash \Box^{\downarrow}_{act}n}[\Box^{\downarrow}E]}{\langle\text{tverb}\rangle^{vhead} \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash s/_{dc>}\Box^{\downarrow}_{pat}n}[/E] \quad \dfrac{\text{dobjc} \vdash \Box^{\downarrow}_{acc}\Box^{\downarrow}_{pat}n}{\langle\text{dobjc}\rangle^{acc} \vdash \Box^{\downarrow}_{pat}n}[\Box^{\downarrow}E]}{(\langle\text{tverb}\rangle^{vhead} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s}[/E]}{(\langle\text{tverb}\rangle^{vinit} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s}[VInit0.l(vhead, vinit)]}{\langle\text{tverb} \circ_{sc>} \langle\text{subje}\rangle^{erg}\rangle^{vinit} \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s}[VInit1.p(vinit, sc>)]}{\langle(\text{tverb} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{vinit} \vdash s}[VInit1.p(vinit, dc>)]}{\langle(\text{tverb} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{mtx} \vdash s}[Matrix\ is\ V-initial]}{(\text{tverb} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash \Box^{\downarrow}_{mtx}s}[\Box^{\downarrow}I]$$

The packages cover VO in general, and thus also cover the (more scarce) VOS languages.

Definition 32 (Rigid verb-initial word order, VFirst). *The* VFirst *package defines the basic controls for establishing that a structure is rigidly verb initial (or V1). It consists of the structural rules given in (446), which are essentially mirroring the rules found in the* VFinal *package (418).*

$$(446)\quad \begin{array}{rcll}
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{vfirst} & [Matrix\ is\ V-first] \\
\langle A\rangle^{sub} & \rightarrow & \langle A\rangle^{vfirst} & [Sub\ is\ V-first] \\
\langle A\rangle^{vfirst}\circ_{sc>}B & \rightarrow & \langle A\rangle^{vhead}\circ_{sc>}B & [VFirst0.l(vhead,vfirst)] \\
\langle A\rangle^{vfirst}\circ_{dc>}B & \rightarrow & \langle A\rangle^{vhead}\circ_{dc>}B & [VFirst0.l(vhead,vfirst)] \\
\langle A\rangle^{vfirst}\circ_{ic>}B & \rightarrow & \langle A\rangle^{vhead}\circ_{ic>}B & [VFirst0.l(vhead,vfirst)] \\
\langle A\circ_{sc>}B\rangle^{vfirst} & \rightarrow & \langle A\rangle^{vfirst}\circ_{sc>}B & [VFirst1.p(vfirst,sc>)] \\
\langle A\circ_{dc>}B\rangle^{vfirst} & \rightarrow & \langle A\rangle^{vfirst}\circ_{dc>}B & [VFirst1.p(vfirst,dc>)] \\
\langle A\circ_{ic>}B\rangle^{vfirst} & \rightarrow & \langle A\rangle^{vfirst}\circ_{ic>}B & [VFirst1.p(vfirst,ic>)]
\end{array}$$

⊛

Remark 29 (Explanation of the VFirst package). The VFirst package defines the basic behavior of the control feature $VFirst$, and its interaction with the standard modes *sc*, *dc* and *ic* as well as the feature *vhead*. The package does not define any variability in word order - it defines rigid SVO. To establish that a clause indeed is rigid in this sense, we need the VFirst package and a goal category $\Box^{\downarrow}{}_{VFirst}S$, (447).

$$(447)\quad \dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\vdots}{(\langle \text{tverb}\rangle^{VFirst}\circ_{sc>}\langle \text{subje}\rangle^{erg})\circ_{dc>}\langle \text{dobjc}\rangle^{acc}\vdash s}\,[VFirst0.l(vhead,VFirst)]}{\langle \text{tverb}\circ_{sc>}\langle \text{subje}\rangle^{erg}\rangle^{VFirst}\circ_{dc>}\langle \text{dobjc}\rangle^{acc}\vdash s}\,[VFirst1.p(VFirst,sc>)]}{\langle(\text{tverb}\circ_{sc>}\langle \text{subje}\rangle^{erg})\circ_{dc>}\langle \text{dobjc}\rangle^{acc}\rangle^{VFirst}\vdash s}\,[VFirst1.p(VFirst,dc>)]}{\langle(\text{tverb}\circ_{sc>}\langle \text{subje}\rangle^{erg})\circ_{dc>}\langle \text{dobjc}\rangle^{acc}\rangle^{mtx}\vdash s}\,[Matrix\ is\ V-initial]}{(\text{tverb}\circ_{sc>}\langle \text{subje}\rangle^{erg})\circ_{dc>}\langle \text{dobjc}\rangle^{acc}\vdash\Box^{\downarrow}{}_{mtx}s}\,[\Box^{\downarrow}I]$$

The derivation in (447) covers VSO order - but the VFirst package is not restricted that that particular word order type. It also covers VOS word order, as we find it in for example Toba Batak, (448).[14]

(448) **Toba Batak**

Mang-ida	si Elijah	si Kathy.
see-ACTIVEV	Elijah	Kathy

"Kathy sees Elijah."

---

[14] ACTIVEV=Active voice, and "si" are proper name markers; cf. (Manning, 1996),p.27ff.

The derivation for a structure that we could assign to (448) is given in (449) below. Naturally, to reflect the fact that VOS is the canonical word order, we start with a verbal category that first takes the object, and then the (ergative) subject.

(449)

$$\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\dfrac{\text{ostverb} \vdash \Box^{\downarrow}{}_{vhead}((s/_{sc>}\Box^{\downarrow}{}_{act}n)/_{dc>}\Box^{\downarrow}{}_{pat}n)}{\langle\text{ostverb}\rangle^{vhead} \vdash (s/_{sc>}\Box^{\downarrow}{}_{act}n)/_{dc>}\Box^{\downarrow}{}_{pat}n}[\Box^{\downarrow}E] \quad \dfrac{\text{dobjc} \vdash \Box^{\downarrow}{}_{acc}\Box^{\downarrow}{}_{pat}n}{\langle\text{dobjc}\rangle^{acc} \vdash \Box^{\downarrow}{}_{pat}n}[\Box^{\downarrow}E]}{\langle\text{ostverb}\rangle^{vhead} \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s/_{sc>}\Box^{\downarrow}{}_{act}n}[/E] \quad \dfrac{\text{subje} \vdash \Box^{\downarrow}{}_{erg}\Box^{\downarrow}{}_{act}n}{\langle\text{subje}\rangle^{erg} \vdash \Box^{\downarrow}{}_{act}n}[\Box^{\downarrow}E]}{(\langle\text{ostverb}\rangle^{vhead} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}) \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash s}[/E]}{(\langle\text{ostverb}\rangle^{vfirst} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}) \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash s}[VFirst0.l(vhead, vfirst)]}{\langle\text{ostverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{vfirst} \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash s}[VFirst1.p(vfirst, dc>)]}{\langle(\text{ostverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}) \circ_{sc>} \langle\text{subje}\rangle^{erg}\rangle^{vfirst} \vdash s}[VFirst1.p(vfirst, sc>)]}{\langle(\text{ostverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}) \circ_{sc>} \langle\text{subje}\rangle^{erg}\rangle^{mtx} \vdash s}[Matrix\ is\ V-first]}{(\text{ostverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}) \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash \Box^{\downarrow}{}_{mtx}s}[\Box^{\downarrow}I]$$

⊛

Definition 33 (Mixed, rigid verb-intial word order, MxVO). *The MxVO package defines the mixed word order pattern for rigidly verb initial languages, extending the VFirst package. MxVO allows for properly case marked dependents to occur in any order, and comprises the rules given in (450).*

(450)

$$\begin{array}{rcll}
\langle A \circ_{ic>} \langle C\rangle^{dat}\rangle^{vfirst} \circ_{dc>} \langle B\rangle^{acc} & \rightarrow & \langle A \circ_{dc>} \langle B\rangle^{acc}\rangle^{vfirst} \circ_{ic>} \langle C\rangle^{dat} & [MxVO0.m(dc, ic)] \\
\langle A \circ_{ic>} \langle C\rangle^{dat}\rangle^{vfirst} \circ_{sc>} \langle B\rangle^{nom} & \rightarrow & \langle A \circ_{sc>} \langle B\rangle^{nom}\rangle^{vfirst} \circ_{ic>} \langle C\rangle^{dat} & [MxVO0.m(sc, ic)] \\
\langle A \circ_{dc>} \langle C\rangle^{acc}\rangle^{vfirst} \circ_{sc>} \langle B\rangle^{nom} & \rightarrow & \langle A \circ_{sc>} \langle B\rangle^{nom}\rangle^{vfirst} \circ_{dc>} \langle C\rangle^{acc} & [MxVO0.m(sc, dc)] \\
\langle (A \circ_{ic>} \langle C\rangle^{dat}) \circ_{dc>} \langle B\rangle^{acc}\rangle^{vfirst} & \rightarrow & \langle (A \circ_{dc>} \langle B\rangle^{acc}) \circ_{ic>} \langle C\rangle^{dat}\rangle^{vfirst} & [MxVO0.m(ic, dc)] \\
\langle (A \circ_{dc>} \langle C\rangle^{acc}) \circ_{sc>} \langle B\rangle^{nom}\rangle^{vfirst} & \rightarrow & \langle (A \circ_{sc>} \langle B\rangle^{nom}) \circ_{dc>} \langle C\rangle^{acc}\rangle^{vfirst} & [MxVO0.m(sc, dc)] \\
\langle (A \circ_{ic>} \langle C\rangle^{dat}) \circ_{sc>} \langle B\rangle^{nom}\rangle^{vfirst} & \rightarrow & \langle (A \circ_{sc>} \langle B\rangle^{nom}) \circ_{ic>} \langle C\rangle^{dat}\rangle^{vfirst} & [MxVO0.m(ic, sc)] \\
\langle A \circ_{ic>} \langle C\rangle^{dat}\rangle^{vfirst} \circ_{sc>} \langle B\rangle^{erg} & \rightarrow & \langle A \circ_{sc>} \langle B\rangle^{erg}\rangle^{vfirst} \circ_{ic>} \langle C\rangle^{dat} & [MxVO0.m(sc, ic)] \\
\langle A \circ_{dc>} \langle C\rangle^{acc}\rangle^{vfirst} \circ_{sc>} \langle B\rangle^{erg} & \rightarrow & \langle A \circ_{sc>} \langle B\rangle^{erg}\rangle^{vfirst} \circ_{dc>} \langle C\rangle^{acc} & [MxVO0.m(sc, dc)] \\
\langle (A \circ_{dc>} \langle C\rangle^{acc}) \circ_{sc>} \langle B\rangle^{erg}\rangle^{vfirst} & \rightarrow & \langle (A \circ_{sc>} \langle B\rangle^{erg}) \circ_{dc>} \langle C\rangle^{acc}\rangle^{vfirst} & [MxVO0.m(sc, dc)] \\
\langle (A \circ_{ic>} \langle C\rangle^{dat}) \circ_{sc>} \langle B\rangle^{erg}\rangle^{vfirst} & \rightarrow & \langle (A \circ_{sc>} \langle B\rangle^{erg}) \circ_{ic>} \langle C\rangle^{dat}\rangle^{vfirst} & [MxVO0.m(ic, sc)]
\end{array}$$

⊛

Remark 30 (Explanation of the MxVO package). The MxVO package allows for dependents to be scrambled, as long as they bear proper case marking. Because some verb initial languages have ergative case marking (rather than absolutive) we have also included behavior for the *erg* feature. The MxVO extends the VFirst package monotonically, and does not alter any of its rigidness in placing the verb initially.

To illustrate the MxVO package, consider the Tagalog examples in (451). The sentence in (451a) gives the canonical order, which we already presented a derivation for in (447). The sentence in (451b) is a variation on (451a), differing in the order of the dependents. The derivation for (451b) necessarily makes use of MxVO, and is given in (452).

(451) **Tagalog**

a. Nagbabasa ang titser ng dyaryo.
read-PAST teacher newspaper
"The teacher read the newspaper"

b. Nagbabasa ng dyaryo ang titser.
read-PAST newspaper teacher
"The teacher read the newspaper"

(452)
$$\begin{array}{cl}
\vdots & \\ \cline{1-1}
(\langle \text{tverb}\rangle^{vfirst} \circ_{sc>} \langle \text{subje}\rangle^{erg}) \circ_{dc>} \langle \text{dobjc}\rangle^{acc} \vdash s & [VFirst0.l(vhead, VFirst)] \\ \cline{1-1}
\langle \text{tverb} \circ_{sc>} \langle \text{subje}\rangle^{erg}\rangle^{vfirst} \circ_{dc>} \langle \text{dobjc}\rangle^{acc} \vdash s & [VFirst1.p(vfirst, sc>)] \\ \cline{1-1}
\langle (\text{tverb} \circ_{sc>} \langle \text{subje}\rangle^{erg}) \circ_{dc>} \langle \text{dobjc}\rangle^{acc}\rangle^{vfirst} \vdash s & [VFirst1.p(vfirst, dc>)] \\ \cline{1-1}
\langle (\text{tverb} \circ_{dc>} \langle \text{dobjc}\rangle^{acc}) \circ_{sc>} \langle \text{subje}\rangle^{erg}\rangle^{vfirst} \vdash s & [MxVO0.m(sc, dc)] \\ \cline{1-1}
\langle (\text{tverb} \circ_{dc>} \langle \text{dobjc}\rangle^{acc}) \circ_{sc>} \langle \text{subje}\rangle^{erg}\rangle^{mtx} \vdash s & [Matrix\ is\ V - initial] \\ \cline{1-1}
(\text{tverb} \circ_{dc>} \langle \text{dobjc}\rangle^{acc}) \circ_{sc>} \langle \text{subje}\rangle^{erg} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

⊛

Just like in the case of OV languages, we may find that a language -occasionally- allows for a dependent to occur *before* the verb, without the word order being free as such. For example, the (Western-Malayo) Polynesian language Chamorro allows for the ergative subject to appear before the verb.

Definition 34 (Non-rigid verb-first languages, NrVO). *The NrVO package defines the possibility for one dependent to occur before the verbal head – non-rigid verb-firstness. The NrVO package consists of the rules in (453).*

(453)
$$\begin{array}{rcll}
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{nrvfirst} & [Matrix\ is\ non - rigid\ vfirst] \\
\langle B \circ_{<sc} A\rangle^{nrvfirst} & \rightarrow & \langle A\rangle^{vfirst} \circ_{sc>} B & [NrVO0.m(sc)]
\end{array}$$

⊛

Remark 31 (Explanation of the NrOV package). Admittedly, the NrOV is not very spectacular. It only allows for the dependent realized as subject to be moved before the verb. The reason for modeling NrOV this way is that our -admittedly limited- observations concerning VO languages all regard ergative languages, and that in such languages non-rigidity is usually reserved for the subject (with a change in voice to alter the dependent that is realized as subject). This also holds for a language like Tagalog. There we can order an element before the verb using a specific construction called *ay*-inversion. Kroeger points out that the inversion is generally restricted to the subject (1993)(p.67ff), but the question is whether to use a structural rule to model this phenomenon or achieve it through a lexical assignment (to *ay*) as Baldridge (2000) proposes. Given Kroeger's observations that there is an interplay between what dependency relation is involved in *ay*-inversion and the information structure, we propose to use a structural rule.

Leaving the Tagalog case at the moment for what it is, we have a look at Chamorro. In Chamorro, we can employ NrVO directly to obtain the desired analysis. Consider the example sentences in (454), from (Chung, 1990), and the derivation in (455) for (454b).

(454) **Chamorro**

a. lumi'e' i lahi i palao'an.
see-PAST man woman
"The man saw the woman"

b. i lahi lumi'e' i palao'an.
man see-PAST woman
"The man saw the woman"

(455)

$$\begin{array}{cl}
\vdots & \\ \hline
(\langle\text{tverb}\rangle^{vfirst} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s & [VFirst0.l(vhead, vfirst)] \\ \hline
\langle\text{tverb} \circ_{sc>} \langle\text{subje}\rangle^{erg}\rangle^{vfirst} \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s & [VFirst1.p(vfirst, sc>)] \\ \hline
\langle\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{vfirst} \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash s & [MxVO0.m(sc, dc)] \\ \hline
\langle\langle\text{subje}\rangle^{erg} \circ_{<sc} (\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc})\rangle^{nrvfirst} \vdash s & [NrVO0.m(sc)] \\ \hline
\langle\langle\text{subje}\rangle^{erg} \circ_{<sc} (\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc})\rangle^{mtx} \vdash s & [Matrix\ is\ non-rigid\ vfirst] \\ \hline
\langle\text{subje}\rangle^{erg} \circ_{<sc} (\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}) \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

⊛

Definition 35 (Free word order in VO languages, FreeVO). *The*

FreeVO package defines freeword order, starting from a VO word order. The package consists of the structural rules given in (456). Just like MxVO, we require that proper case marking is present for a structure to appear in position different from the canonical one.

$$
\begin{array}{rcll}
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{free} & [Matrix\ is\ free] \\
\langle A\rangle^{free} & \rightarrow & \langle A\rangle^{vfirst} & [FreeVO0.l(free, vfirst)] \\
\langle A\rangle^{free} & \rightarrow & \langle A\rangle^{nrvfirst} & [FreeVO0.l(free, nrvfirst)] \\
\langle\langle B\rangle^{nom} \circ_{<sc} A\rangle^{free} & \rightarrow & \langle A \circ_{sc>} \langle B\rangle^{nom}\rangle^{free} & [FreeVO1.m(sc)] \\
\langle\langle C\rangle^{acc} \circ_{<dc} (A \circ_{<sc} B)\rangle^{free} & \rightarrow & \langle A \circ_{<sc} (B \circ_{dc>} \langle C\rangle^{acc})\rangle^{free} & [FreeVO1.m(dc, sc)] \\
\langle\langle C\rangle^{dat} \circ_{<ic} (A \circ_{<dc} B)\rangle^{free} & \rightarrow & \langle A \circ_{<dc} (B \circ_{ic>} \langle C\rangle^{dat})\rangle^{free} & [FreeVO1.m(dc, ic)] \\
(A \circ_{sc>} B) \circ_{ic>} C & \rightarrow & A \circ_{<sc} (B \circ_{ic>} C) & [FreeVO2.assc(sc, ic)] \\
\langle\langle B\rangle^{acc} \circ_{<dc} (\langle A\rangle^{dat} \circ_{<ic} C)\rangle^{free} & \rightarrow & \langle\langle A\rangle^{dat} \circ_{<ic} (\langle B\rangle^{acc} \circ_{<dc} C)\rangle^{free} & [FreeVO3.m(ic, dc)] \\
\langle\langle B\rangle^{nom} \circ_{<sc} (\langle A\rangle^{dat} \circ_{<ic} C)\rangle^{free} & \rightarrow & \langle\langle A\rangle^{dat} \circ_{<ic} (\langle B\rangle^{nom} \circ_{<sc} C)\rangle^{free} & [FreeVO3.m(ic, sc)] \\
\langle\langle B\rangle^{erg} \circ_{<sc} (\langle A\rangle^{dat} \circ_{<ic} C)\rangle^{free} & \rightarrow & \langle\langle A\rangle^{dat} \circ_{<ic} (\langle B\rangle^{erg} \circ_{<sc} C)\rangle^{free} & [FreeVO3.m(ic, sc)] \\
\langle\langle B\rangle^{nom} \circ_{<sc} (\langle A\rangle^{acc} \circ_{<dc} C)\rangle^{free} & \rightarrow & \langle\langle A\rangle^{acc} \circ_{<dc} (\langle B\rangle^{nom} \circ_{<sc} C)\rangle^{free} & [FreeVO3.m(dc, sc)] \\
\langle\langle B\rangle^{erg} \circ_{<sc} (\langle A\rangle^{acc} \circ_{<dc} C)\rangle^{free} & \rightarrow & \langle\langle A\rangle^{acc} \circ_{<dc} (\langle B\rangle^{erg} \circ_{<sc} C)\rangle^{free} & [FreeVO3.m(dc, sc)] \\
\langle A \circ_{<sc} B\rangle^{free} & \rightarrow & A \circ_{<sc} \langle B\rangle^{free} & [FreeVO4.p(free, sc)] \\
A \circ_{<sc} \langle B\rangle^{free} & \rightarrow & \langle A \circ_{<sc} B\rangle^{free} & [FreeVO4.p(free, sc)] \\
\langle A \circ_{<dc} B\rangle^{free} & \rightarrow & A \circ_{<dc} \langle B\rangle^{free} & [FreeVO4.p(free, dc)] \\
A \circ_{<dc} \langle B\rangle^{free} & \rightarrow & \langle A \circ_{<dc} B\rangle^{free} & [FreeVO4.p(free, dc)] \\
\langle A \circ_{<ic} B\rangle^{free} & \rightarrow & A \circ_{<ic} \langle B\rangle^{free} & [FreeVO4.p(free, ic)] \\
A \circ_{<ic} \langle B\rangle^{free} & \rightarrow & \langle A \circ_{<ic} B\rangle^{free} & [FreeVO4.p(free, ic)]
\end{array}
\tag{456}
$$

⊛

Remark 32 (Explanation of the FreeVO package). Just like in the FreeOV package, we control the accessibility of FreeVO's structural rules using a *free* feature. The FreeVO package monotonically extends the VFirst, MxVO and NrVO packages, so -again- we may have that in the process of constructing a derivation we obtain structures that can be analyzed in terms of these more restrictive packages. The derivation in (457) examplifies this.

$$(457)\quad \begin{array}{c l}
\vdots & \\ \cline{1-1}
(\langle\text{tverb}\rangle^{vfirst} \circ_{sc>} \langle\text{subje}\rangle^{erg}) \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s & [VFirst0.l(vhead, vfirst)] \\ \cline{1-1}
\langle\text{tverb} \circ_{sc>} \langle\text{subje}\rangle^{erg}\rangle^{vfirst} \circ_{dc>} \langle\text{dobjc}\rangle^{acc} \vdash s & [VFirst1.p(vfirst, sc>)] \\ \cline{1-1}
\langle\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc}\rangle^{vfirst} \circ_{sc>} \langle\text{subje}\rangle^{erg} \vdash s & [MxVO0.m(sc, dc)] \\ \cline{1-1}
\langle\langle\text{subje}\rangle^{erg} \circ_{<sc} (\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc})\rangle^{nrvfirst} \vdash s & [NrVO0.m(sc)] \\ \cline{1-1}
\langle\langle\text{subje}\rangle^{erg} \circ_{<sc} (\text{tverb} \circ_{dc>} \langle\text{dobjc}\rangle^{acc})\rangle^{free} \vdash s & [FreeVO0.l(free, nrvfirst)] \\ \cline{1-1}
\langle\langle\text{dobjc}\rangle^{acc} \circ_{<dc} (\langle\text{subje}\rangle^{erg} \circ_{<sc} \text{tverb})\rangle^{free} \vdash s & [FreeVO1.m(dc, sc)] \\ \cline{1-1}
\langle\langle\text{subje}\rangle^{erg} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{free} \vdash s & [FreeVO3.m(dc, sc)] \\ \cline{1-1}
\langle\langle\text{subje}\rangle^{erg} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb})\rangle^{mtx} \vdash s & [Matrix\ is\ free] \\ \cline{1-1}
\langle\text{subje}\rangle^{erg} \circ_{<sc} (\langle\text{dobjc}\rangle^{acc} \circ_{<dc} \text{tverb}) \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

We do not define here any packages that allow for mixed or free word order of elements that are not properly marked for case. If one were to observe such a language, then the MxVO and FreeVO packages can be extended to MxVOnc and FreeVOnc by simply leaving off the case features, analagously to the derivation of MxOVnc and FreeOVnc from MxOV and FreeOV.

7.3.4 SVO PACKAGES

In the current section we define a number of packages that describe word order behavior which might be available to a language that is SVO at one clause level or another. Figure 7.4 gives a concise overview of the packages and their interrelations.

The packages are based on the assumption that the lexicon assigns a basic word order as shown in (458).

(458) $(A \circ_{\prec sc} ((B \circ_{dc\succ} C) \circ_{ic\succ} D))$

Before we go and define the packages, we should first consider what “the structure” of SVO is - or, at least, what view we adhere to here. For example, Figure 7.5 illustrates the possible ways in which we can conceive of the (initial, or canonical) structuring of SVO clauses.

The Rigid SVO picture shows just the basic word order as in (458). A slightly more complex situation arises when we add the Wackernagel position to this configuration. Following FGD, we characterize the Wackernagel position as to be -in general- the position right after the first *dependent*.[15]

---

[15] Data from for example Czech shows quite obviously that it is not the first *constituent*, or even the first *phrase*. A phrase-structure grammar does not lend itself to a satisfactory

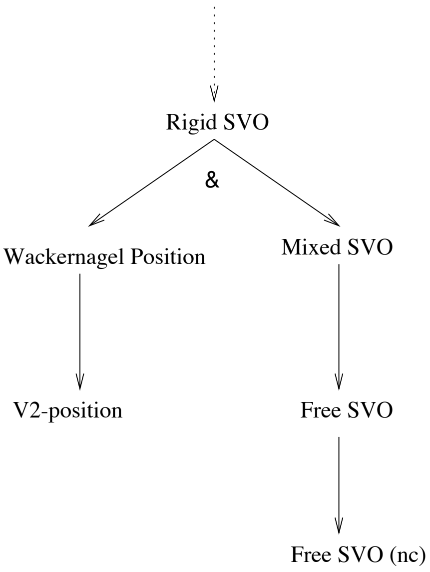

Figure 7.4: Architecture of SVO packages

More interesting situations arise in the case of verb secondness, either with rigid or mixed SVO word order. A language that has a verb second SVO word order also has a verb final cluster. This splits the structure up into several domains or "fields": the domain before the second (Wackernagel) position, the verb-final cluster, and the domain between the cluster and the second position. In Germanic linguistics, these different domains are usually called the *Vorfeld*, the *Nachfeld*, and the *Mittelfeld* respectively.

Languages that are verb second SVO are most often mixed word order languages, like Dutch or German (with Swedish an exception we noted in Chapter 6). Thus, because word order can be mixed, we get a *communication* between the Vorfeld and the Mittelfeld. Verbal dependents within the Mittelfeld can be scrambled, and can be 'exchanged' with *the* dependent in the Vorfeld (as verb secondness needs to be maintained). If a language is free but still does distinguish a Wackernagel position, we get the more general situation that dependents can be either placed in the domain before

---

definition of the Wackernagel position, in other words. Sgall (p.c.) notes that, in a more detailed way, the view FGD is as follows: The Wackernagel position is (prototypically, if not always), (i) the surface position directly following after the position of the first item in the upper subtree if the surface word order corresponds to the underlying positions of the subtree; (ii) if one of the deeper embedded items is shifted to the left (as in **Czech** "Jirku jsme plánovali poslat do Francii") then the Wackernagel position is after the head of the shifted subtree ("jsme"); (iii) some other shifts may be necessary to specify other possibilities.

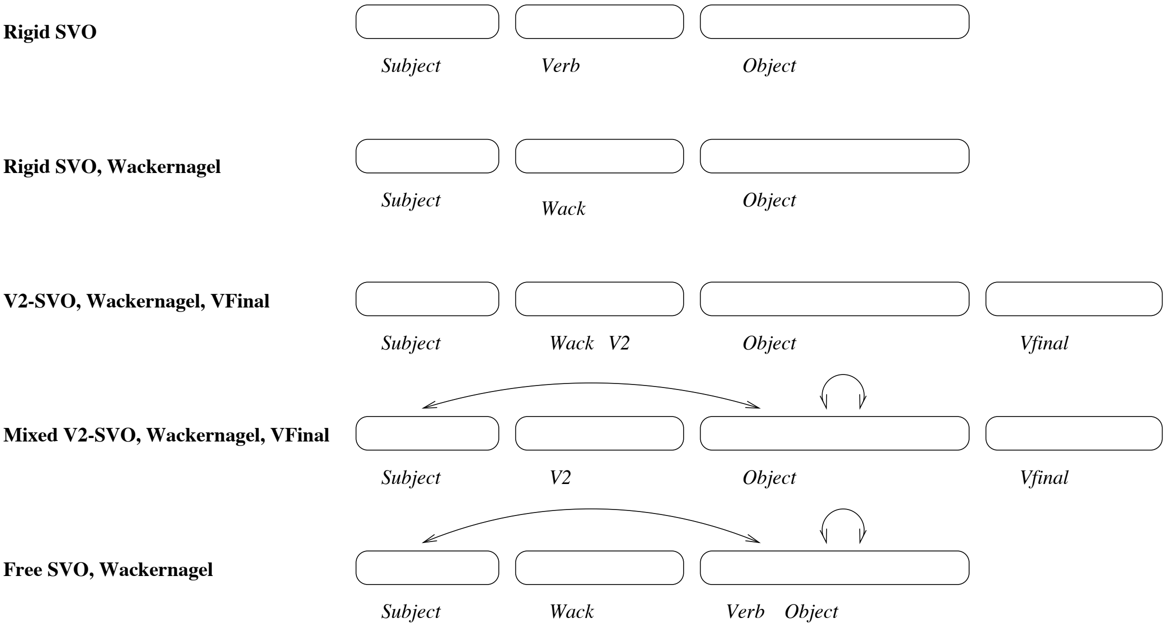

Figure 7.5: Structuring of SVO word order

the Wackernagel position or after it - just as long the Wackernagel position is indeed in its right place.

Definition 36 (Wackernagel Position, SVO.Wack). *The Wack package defines structural rules that characterize the Wackernagel position. We consider the Wackernagel position to be -in general- the position after the first dependent. The structural rules given in (459) implement that viewpoint, immediately for the rigid (r) and mixed (m) cases. The free (f) word order cases are defined in (469) on page 267, in the definition of the FreeSVO package.*

(459)

$$\begin{array}{rcll}
\langle A \circ_{<sc} (B \circ_{dc>} C)\rangle^{wack} & \rightarrow & A \circ_{<sc} (\langle B\rangle^{wack} \circ_{dc>} C) & [SVO.Wack0(r).p(wack, sc)] \\
\langle A \circ_{<sc} (B \circ_{ic>} C)\rangle^{wack} & \rightarrow & A \circ_{<sc} (\langle B\rangle^{wack} \circ_{ic>} C) & [SVO.Wack0(r).p(wack, sc)] \\
\langle A \circ_{<sc} (B \circ_{<aux} C)\rangle^{wack} & \rightarrow & A \circ_{<sc} (\langle B\rangle^{wack} \circ_{<aux} C) & [SVO.Wack0(r).p(wack, sc)] \\
\langle A \circ_{<sc} (B \circ_{<mod} C)\rangle^{wack} & \rightarrow & A \circ_{<sc} (\langle B\rangle^{wack} \circ_{<mod} C) & [SVO.Wack0(r).p(wack, sc)] \\
\langle A \circ_{<dc} (B \circ_{sc>} C)\rangle^{wack} & \rightarrow & A \circ_{<dc} (\langle B\rangle^{wack} \circ_{sc>} C) & [SVO.Wack0(m).p(wack, dc)] \\
\langle A \circ_{<dc} (B \circ_{ic>} C)\rangle^{wack} & \rightarrow & A \circ_{<dc} (\langle B\rangle^{wack} \circ_{ic>} C) & [SVO.Wack0(m).p(wack, dc)] \\
\langle A \circ_{<ic} (B \circ_{sc>} C)\rangle^{wack} & \rightarrow & A \circ_{<ic} (\langle B\rangle^{wack} \circ_{sc>} C) & [SVO.Wack0(m).p(wack, ic)] \\
\langle A \circ_{<ic} (B \circ_{dc>} C)\rangle^{wack} & \rightarrow & A \circ_{<ic} (\langle B\rangle^{wack} \circ_{dc>} C) & [SVO.Wack0(m).p(wack, ic)] \\
\langle A \circ_{<dc} (B \circ_{<aux} C)\rangle^{wack} & \rightarrow & A \circ_{<dc} (\langle B\rangle^{wack} \circ_{<aux} C) & [SVO.Wack0(m).p(wack, dc)] \\
\langle A \circ_{<dc} (B \circ_{<mod} C)\rangle^{wack} & \rightarrow & A \circ_{<dc} (\langle B\rangle^{wack} \circ_{<mod} C) & [SVO.Wack0(m).p(wack, dc)] \\
\langle A \circ_{<ic} (B \circ_{<aux} C)\rangle^{wack} & \rightarrow & A \circ_{<ic} (\langle B\rangle^{wack} \circ_{<aux} C) & [SVO.Wack0(m).p(wack, ic)] \\
\langle A \circ_{<ic} (B \circ_{<mod} C)\rangle^{wack} & \rightarrow & A \circ_{<ic} (\langle B\rangle^{wack} \circ_{<mod} C) & [SVO.Wack0(m).p(wack, ic)] \\
\langle \langle A\rangle^{vhead} \circ_{sc>} (B \circ_{dc>} C)\rangle^{wack} & \rightarrow & \langle A\rangle^{vhead} \circ_{sc>} (\langle B\rangle^{wack} \circ_{dc>} C) & [SVO.Wack0(f).p(wack, sc)] \\
\langle \langle A\rangle^{vhead} \circ_{sc>} (B \circ_{dc>} C)\rangle^{wack} & \rightarrow & \langle A\rangle^{vhead} \circ_{sc>} (\langle B\rangle^{wack} \circ_{dc>} C) & [SVO.Wack0(f).p(wack, sc)] \\
\langle \langle A\rangle^{vhead} \circ_{dc>} (B \circ_{sc>} C)\rangle^{wack} & \rightarrow & \langle A\rangle^{vhead} \circ_{dc>} (\langle B\rangle^{wack} \circ_{sc>} C) & [SVO.Wack0(f).p(wack, dc)] \\
\langle \langle A\rangle^{vhead} \circ_{dc>} (B \circ_{ic>} C)\rangle^{wack} & \rightarrow & \langle A\rangle^{vhead} \circ_{dc>} (\langle B\rangle^{wack} \circ_{ic>} C) & [SVO.Wack0(f).p(wack, dc)] \\
\langle \langle A\rangle^{vhead} \circ_{ic>} (B \circ_{sc>} C)\rangle^{wack} & \rightarrow & \langle A\rangle^{vhead} \circ_{ic>} (\langle B\rangle^{wack} \circ_{sc>} C) & [SVO.Wack0(f).p(wack, ic)] \\
\langle \langle A\rangle^{vhead} \circ_{ic>} (B \circ_{dc>} C)\rangle^{wack} & \rightarrow & \langle A\rangle^{vhead} \circ_{ic>} (\langle B\rangle^{wack} \circ_{dc>} C) & [SVO.Wack0(f).p(wack, ic)]
\end{array}$$

⊛

Remark 33 (Explanation of the SVO.Wack package). The Wack package defines a "general purpose" set of structural rules that can be used in any word order setting. The package as such does not define *any* ordering. All its structural rules do is define what the Wackernagel position is in various settings, with "definition" meaning that a a *wack* feature can only be percolated to a higher level if and only if the element originally labeled with that feature is in the right position (i.e. the Wackernagel position).

The Wack package serves as the foundation for various, more specific accounts. Below we detail out the V2nd packages, which extend the Wack package to model verb secondness. ⊛

Definition 37 (Verb-second position, SVO.Wack.V2nd). *The V2nd package is a simple extension to the Wack package, to define verb secondness in (rigid/mixed) SVO languages. The V2nd package comprises the structural rules given in (460).*

(460)

$$\begin{array}{rcll}
\langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{v2} & [Matrix\ is\ V2nd] \\
\langle A\rangle^{v2} & \rightarrow & \langle A\rangle^{wack} & [V2nd\ is\ Wack] \\
A \circ_{<sc} (\langle B\rangle^{wack} \circ_{<mod} C) & \rightarrow & A \circ_{<sc} (\langle B\rangle^{v2} \circ_{<mod} C) & [SVO.Wack.V2nd0.l(v2, wack)] \\
A \circ_{<sc} (\langle B\rangle^{wack} \circ_{<aux} C) & \rightarrow & A \circ_{<sc} (\langle B\rangle^{v2} \circ_{<aux} C) & [SVO.Wack.V2nd0.l(v2, wack)] \\
A \circ_{<sc} (\langle B\rangle^{wack} \circ_{dc>} C) & \rightarrow & A \circ_{<sc} (\langle B\rangle^{vhead} \circ_{dc>} C) & [SVO.Wack.V2nd0.l(vhead, wack)]
\end{array}$$

Because a requirement for verb secondness is almost invariably accompanied by a requirement for certain verbs to be verb final, the following rules from VFinal *should be combined with (460) to account for that, and one of the* *Dep *packages to determine the order in the verb final cluster.*

(461)
$$\begin{array}{lll} A \circ_{<dc} \langle B\rangle^{vfinal} \rightarrow A \circ_{<dc} \langle B\rangle^{vhead} & [VFinal0.l(vhead, vfinal)] \\ A \circ_{<ic} \langle B\rangle^{vfinal} \rightarrow A \circ_{<ic} \langle B\rangle^{vhead} & [VFinal0.l(vhead, vfinal)] \\ \langle A \circ_{<dc} B\rangle^{vfinal} \rightarrow A \circ_{<dc} \langle B\rangle^{vfinal} & [VFinal1.p(vfinal, < dc)] \\ \langle A \circ_{<ic} B\rangle^{vfinal} \rightarrow A \circ_{<ic} \langle B\rangle^{vfinal} & [VFinal1.p(vfinal, < ic)] \end{array}$$

⊛

Remark 34 (Explanation of the V2nd package). The V2nd package is, as said, a simple extension to the Wack package. Because the latter already the important aspect of defining the "verb second" or Wackernagel position, all the V2nd package does is specifying what should appear in that position for that element (and the clause) to be verb second. Particularly, a clause is verb second if it either has the verbal head in the second position (rule $V2nd0.l(vhead, wack)$), or if it has the (modal) auxiliary in that position ($V2nd0.l(v2, wack)$). In the latter case, the verbal head itself is then -mostly- required to be in verb final position.

To illustrate the V2nd package, consider first the Dutch sentence in (462), with the formal lexical entries as given in (463).

(462) **Dutch**

Christopher wil boeken lezen.
Christopher wants books to read

"Christopher wants to read books."

(463) **Lexicon**:
christopher : $\Box^{\downarrow}{}_{act} n$
boeken : $\Box^{\downarrow}{}_{pat} n$
wil : $\Box^{\downarrow}{}_{v2}((\Box^{\downarrow}{}_{act} n \backslash_{<sc} s)/_{<mod} \Box^{\downarrow}{}_{vfinal}(\Box^{\downarrow}{}_{act} n \backslash_{<sc} sinf))$
lezen : $\Box^{\downarrow}{}_{vhead}(\Box^{\downarrow}{}_{pat} n \backslash_{<dc}(\Box^{\downarrow}{}_{act} n \backslash_{<sc} sinf))$

Observe that the modal auxiliary "wil" imposes two requirements. First of all, it needs the infinite (and any of its arguments) to form a verb final structure, due to the $\Box^{\downarrow}{}_{vfinal}$. Secondly, it states that it has to appear itself in the verb second position, $\Box^{\downarrow}{}_{v2}$. Because we give as goal-category

$\Box^{\downarrow}{}_{mtx}S$ which then rewrites to $\Box^{\downarrow}{}_{v2}S$ (verb-second matrix clause), all these requirements have to be met. The derivation in (464) shows how this is done.

$$(464)\qquad \begin{array}{ll}
\vdots & \\ \hline
\text{christopher} \circ_{<sc}(\langle\text{wil}\rangle^{wack} \circ_{<mod}(\text{boeken} \circ_{<dc}\text{lezen})) \vdash s & [SVO.Wack.V2nd0.l(v2, wack)] \\ \hline
\langle\text{christopher} \circ_{<sc}(\text{wil} \circ_{<mod}(\text{boeken} \circ_{<dc}\text{lezen}))\rangle^{wack} \vdash s & [SVO.Wack0(r).p(wack, sc)] \\ \hline
\langle\text{christopher} \circ_{<sc}(\text{wil} \circ_{<mod}(\text{boeken} \circ_{<dc}\text{lezen}))\rangle^{v2} \vdash s & [V2nd \ is \ Wack] \\ \hline
\langle\text{christopher} \circ_{<sc}(\text{wil} \circ_{<mod}(\text{boeken} \circ_{<dc}\text{lezen}))\rangle^{mtx} \vdash s & [Matrix \ is \ V2nd] \\ \hline
\text{christopher} \circ_{<sc}(\text{wil} \circ_{<mod}(\text{boeken} \circ_{<dc}\text{lezen})) \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

⊛

Definition 38 (SVO mixed word order, SVO.MxSVO). *The MxSVO package models mixed word order in SVO languages. The structural rules are given in (465).*

$$(465)\qquad \begin{array}{rcll}
\langle B\rangle^{wack} \circ_{<aux}(A \circ_{<sc}C) & \to & A \circ_{<sc}(\langle B\rangle^{wack} \circ_{<aux}C) & [MxSVO1.m(sc, aux)] \\
\langle B\rangle^{wack} \circ_{<mod}(A \circ_{<sc}C) & \to & A \circ_{<sc}(\langle B\rangle^{wack} \circ_{<mod}C) & [MxSVO1.m(sc, mod)] \\
\langle B\rangle^{wack} \circ_{<aux}(A \circ_{<dc}C) & \to & A \circ_{<dc}(\langle B\rangle^{wack} \circ_{<aux}C) & [MxSVO1.m(dc, aux)] \\
\langle B\rangle^{wack} \circ_{<mod}(A \circ_{<dc}C) & \to & A \circ_{<dc}(\langle B\rangle^{wack} \circ_{<mod}C) & [MxSVO1.m(dc, mod)] \\
\langle B\rangle^{wack} \circ_{<aux}(A \circ_{<ic}C) & \to & A \circ_{<ic}(\langle B\rangle^{wack} \circ_{<aux}C) & [MxSVO1.m(ic, aux)] \\
\langle B\rangle^{wack} \circ_{<mod}(A \circ_{<ic}C) & \to & A \circ_{<ic}(\langle B\rangle^{wack} \circ_{<mod}C) & [MxSVO1.m(ic, mod)] \\
B \circ_{<dc}(\langle A\rangle^{wack} \circ_{<aux}C) & \to & \langle A\rangle^{wack} \circ_{<aux}(B \circ_{<dc}C) & [MxSVO2.m(aux, dc)] \\
B \circ_{<ic}(\langle A\rangle^{wack} \circ_{<aux}C) & \to & \langle A\rangle^{wack} \circ_{<aux}(B \circ_{<ic}C) & [MxSVO2.m(aux, ic)] \\
B \circ_{<dc}(\langle A\rangle^{wack} \circ_{<mod}C) & \to & \langle A\rangle^{wack} \circ_{<mod}(B \circ_{<dc}C) & [MxSVO2.m(mod, dc)] \\
B \circ_{<ic}(\langle A\rangle^{wack} \circ_{<mod}C) & \to & \langle A\rangle^{wack} \circ_{<mod}(B \circ_{<ic}C) & [MxSVO2.m(mod, ic)] \\
B \circ_{<dc}(A \circ_{<sc}C) & \to & A \circ_{<sc}(B \circ_{<dc}C) & [MxSVO3.m(sc, dc)] \\
B \circ_{<sc}(A \circ_{<ic}C) & \to & A \circ_{<ic}(B \circ_{<sc}C) & [MxSVO3.m(sc, ic)] \\
B \circ_{<ic}(A \circ_{<sc}C) & \to & A \circ_{<sc}(B \circ_{<ic}C) & [MxSVO3.m(sc, ic)] \\
B \circ_{<ic}(A \circ_{<dc}C) & \to & A \circ_{<dc}(B \circ_{<ic}C) & [MxSVO3.m(dc, ic)] \\
B \circ_{<dc}(A \circ_{<ic}C) & \to & A \circ_{<ic}(B \circ_{<dc}C) & [MxSVO3.m(ic, dc)] \\
C \circ_{<dc}(B \circ_{sc>}A) & \to & A \circ_{<sc}(B \circ_{dc>}C) & [MxSVO4.m(sc, dc)] \\
C \circ_{<ic}(B \circ_{sc>}A) & \to & A \circ_{<sc}(B \circ_{ic>}C) & [MxSVO4.m(sc, ic)] \\
(A \circ_{ic>}C) \circ_{dc>}B & \to & (A \circ_{dc>}B) \circ_{ic>}C & [MxSVO4.m(ic, dc)] \\
(A \circ_{sc>}C) \circ_{dc>}B & \to & (A \circ_{dc>}B) \circ_{sc>}C & [MxSVO4.m(sc, dc)] \\
(A \circ_{sc>}C) \circ_{ic>}B & \to & (A \circ_{ic>}B) \circ_{sc>}C & [MxSVO4.m(sc, ic)]
\end{array}$$

Remark 35 (Explanation of the MxSVO package). There are several observations we should make about the structural rules in (465). First of all, the package has been designed such that it relies on the Wack package to be present. Although the contraint that B should be marked with *wack* could be relaxed, there is a linguistic reason why we modeled MxSVO *with* this constraint. This reason is simple: It follows from the definition of what it means to be mixed SVO, (Steele, 1978). In general, it tends to hold that mixed SVO languages have a requirement for verb secondness - witness Dutch and German. Towards the end of rigid SVO languages we have for example English, which does not have such a requirement, and neither does a free SVO language like Czech.

Secondly, we obtain a communication between the Vorfeld and the Mittelfeld in the following way. The MxSVO1.* "temporarily move aside", as it were, to allow the dependent from the Vorfeld to combine with the dependent(s) from the Mittelfeld. The MxSVO3.* enable any ordering of the dependents to obtain, after which the MxSVO2.* rules move a dependent from the Mittelfeld back into the Vorfeld. The latter step *has* to be made, because otherwise we would have an element that requires to be in the Wackernagel position, but is not. And the step *is* made, if we have a goal category $\Box^{\downarrow}{}_{mtx}S$, because the *wack* feature only distributes if the such marked element is indeed in the right position (rules SVO.Wack0(m).*).

To illustrate the MxSVO package, consider the Dutch examples in (466). These are all valid variations, among other possible ones. An analysis for (466b) is given below, in (467).

(466) **Dutch**

a. Christopher wil boeken aan Kathy voorlezen.
Christopher wants books to Kathy to read
"Christopher wants to read books to Kathy."

b. Boeken wil Christopher aan Kathy voorlezen.

c. Christopher wil aan Kathy boeken voorlezen.

(467)

$$\begin{array}{c l}
\vdots & \\ \hline
\text{christopher} \circ <_{sc}(\langle \text{wil}\rangle^{wack} \circ <_{mod}(\text{boeken} \circ <_{dc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen}))) \vdash s & [SVO.Wack.V2nd0.l(v2, wack)] \\ \hline
\langle \text{wil}\rangle^{wack} \circ <_{mod}(\text{christopher} \circ <_{sc}(\text{boeken} \circ <_{dc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen}))) \vdash s & [MxSVO1.m(sc, mod)] \\ \hline
\langle \text{wil}\rangle^{wack} \circ <_{mod}(\text{boeken} \circ <_{dc}(\text{christopher} \circ <_{sc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen}))) \vdash s & [MxSVO3.m(sc, dc)] \\ \hline
\text{boeken} \circ <_{dc}(\langle \text{wil}\rangle^{wack} \circ <_{mod}(\text{christopher} \circ <_{sc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen}))) \vdash s & [MxSVO2.m(mod, dc)] \\ \hline
\langle \text{boeken} \circ <_{dc}(\text{wil} \circ <_{mod}(\text{christopher} \circ <_{sc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen})))\rangle^{wack} \vdash s & [SVO.Wack0(r).p(wack, dc)] \\ \hline
\langle \text{boeken} \circ <_{dc}(\text{wil} \circ <_{mod}(\text{christopher} \circ <_{sc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen})))\rangle^{v2} \vdash s & [V2nd\ is\ Wack] \\ \hline
\langle \text{boeken} \circ <_{dc}(\text{wil} \circ <_{mod}(\text{christopher} \circ <_{sc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen})))\rangle^{mtx} \vdash s & [Matrix\ is\ V2nd] \\ \hline
\text{boeken} \circ <_{dc}(\text{wil} \circ <_{mod}(\text{christopher} \circ <_{sc}((\text{aan} \circ <_{prep}\text{kathy}) \circ <_{ic}\text{voorlezen}))) \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

⊛

Definition 39 (SVO free word order, SVO.FreeSVO). *The FreeSVO package defines free word order for SVO languages. It can be used in conjunction with the MxSVO package, and consists of the structural rules given in (468). The extension to the Wack package, to deal with full free word order, is given below in (469).*

$$
\begin{array}{lrcll}
 & \langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{wack} & [Matrix\ obeys\ Wack] \\
 & \langle A\rangle^{mtx} & \rightarrow & \langle A\rangle^{free} & [Matrix\ is\ free] \\
 & \langle B\rangle^{vhead}\circ_{mod>}(\langle A\rangle^{wack}\circ_{sc>}C) & \rightarrow & \langle A\rangle^{wack}\circ_{<mod}(\langle B\rangle^{vhead}\circ_{sc>}C) & [FreeSVO1.m(vhead,mod)] \\
(468) & \langle B\rangle^{vhead}\circ_{aux>}(\langle A\rangle^{wack}\circ_{sc>}C) & \rightarrow & \langle A\rangle^{wack}\circ_{<aux}(\langle B\rangle^{vhead}\circ_{sc>}C) & [FreeSVO1.m(vhead,aux)] \\
 & (\langle B\rangle^{vhead}\circ_{sc>}A)\circ_{dc>}C & \rightarrow & A\circ_{<sc}(\langle B\rangle^{vhead}\circ_{dc>}C) & [FreeSVO1.m(vhead,sc)] \\
 & (A\circ_{dc>}C)\circ_{sc>}B & \rightarrow & (A\circ_{sc>}B)\circ_{dc>}C & [FreeSVO1.m(dc,sc)] \\
 & A\circ_{<sc}(C\circ_{<dc}\langle B\rangle^{vhead}) & \rightarrow & A\circ_{<sc}(\langle B\rangle^{vhead}\circ_{dc>}C) & [FreeSVO1.m(vhead,dc)]
\end{array}
$$

$$
\begin{array}{lrcll}
 & \langle\langle A\rangle^{vhead}\circ_{mod>}(B\circ_{sc>}C)\rangle^{free} & \rightarrow & \langle A\rangle^{vhead}\circ_{mod>}(\langle B\rangle^{wack}\circ_{sc>}C) & [SVO.Wack0(f).p(wack,mod)] \\
 & \langle\langle A\rangle^{vhead}\circ_{mod>}(B\circ_{dc>}C)\rangle^{free} & \rightarrow & \langle A\rangle^{vhead}\circ_{mod>}(\langle B\rangle^{wack}\circ_{dc>}C) & [SVO.Wack0(f).p(wack,mod)] \\
 & \langle\langle A\rangle^{vhead}\circ_{mod>}(B\circ_{ic>}C)\rangle^{free} & \rightarrow & \langle A\rangle^{vhead}\circ_{mod>}(\langle B\rangle^{wack}\circ_{ic>}C) & [SVO.Wack0(f).p(wack,mod)] \\
 & \langle\langle A\rangle^{vhead}\circ_{aux>}(B\circ_{sc>}C)\rangle^{free} & \rightarrow & \langle A\rangle^{vhead}\circ_{aux>}(\langle B\rangle^{wack}\circ_{sc>}C) & [SVO.Wack0(f).p(wack,aux)] \\
 & \langle\langle A\rangle^{vhead}\circ_{aux>}(B\circ_{dc>}C)\rangle^{free} & \rightarrow & \langle A\rangle^{vhead}\circ_{aux>}(\langle B\rangle^{wack}\circ_{dc>}C) & [SVO.Wack0(f).p(wack,aux)] \\
 & \langle\langle A\rangle^{vhead}\circ_{aux>}(B\circ_{ic>}C)\rangle^{free} & \rightarrow & \langle A\rangle^{vhead}\circ_{aux>}(\langle B\rangle^{wack}\circ_{ic>}C) & [SVO.Wack0(f).p(wack,aux)] \\
 & \langle A\circ_{<sc}(B\circ_{dc>}C)\rangle^{free} & \rightarrow & A\circ_{<sc}(\langle B\rangle^{wack}\circ_{dc>}C) & [SVO.Wack0(f).p(wack,sc)] \\
 & \langle A\circ_{<sc}(B\circ_{ic>}C)\rangle^{free} & \rightarrow & A\circ_{<sc}(\langle B\rangle^{wack}\circ_{ic>}C) & [SVO.Wack0(f).p(wack,sc)] \\
 & \langle A\circ_{<dc}(B\circ_{sc>}C)\rangle^{free} & \rightarrow & A\circ_{<dc}(\langle B\rangle^{wack}\circ_{sc>}C) & [SVO.Wack0(f).p(wack,dc)] \\
(469) & \langle A\circ_{<dc}(B\circ_{ic>}C)\rangle^{free} & \rightarrow & A\circ_{<dc}(\langle B\rangle^{wack}\circ_{ic>}C) & [SVO.Wack0(f).p(wack,dc)] \\
 & \langle A\circ_{<ic}(B\circ_{sc>}C)\rangle^{free} & \rightarrow & A\circ_{<ic}(\langle B\rangle^{wack}\circ_{sc>}C) & [SVO.Wack0(f).p(wack,ic)] \\
 & \langle A\circ_{<ic}(B\circ_{dc>}C)\rangle^{free} & \rightarrow & A\circ_{<ic}(\langle B\rangle^{wack}\circ_{dc>}C) & [SVO.Wack0(f).p(wack,ic)] \\
 & \langle A\rangle^{free} & \rightarrow & \langle A\rangle^{vhead} & [FreeSVO.l(vhead,free)] \\
 & \langle A\circ_{sc>}B\rangle^{free} & \rightarrow & \langle A\rangle^{free}\circ_{sc>}B & [FreeSVO.p(free,sc)] \\
 & \langle A\circ_{dc>}B\rangle^{free} & \rightarrow & \langle A\rangle^{free}\circ_{dc>}B & [FreeSVO.p(free,dc)] \\
 & \langle A\circ_{ic>}B\rangle^{free} & \rightarrow & \langle A\rangle^{free}\circ_{ic>}B & [FreeSVO.p(free,ic)] \\
 & \langle A\circ_{<sc}B\rangle^{free} & \rightarrow & A\circ_{<sc}\langle B\rangle^{free} & [FreeSVO.p(free,sc)] \\
 & \langle A\circ_{<dc}B\rangle^{free} & \rightarrow & A\circ_{<dc}\langle B\rangle^{free} & [FreeSVO.p(free,dc)] \\
 & \langle A\circ_{<ic}B\rangle^{free} & \rightarrow & A\circ_{<ic}\langle B\rangle^{free} & [FreeSVO.p(free,ic)]
\end{array}
$$

⊛

Remark 36 (Explanation of the FreeSVO package). The FreeSVO package extends the MxSVO package, essentially by allowing the verbal head to occur in any position as well. We briefly define the interaction with any elements requiring to be placed in the Wackernagel position, with the majority of the control structural rules being placed in the Wack package, (469). Although the number of rules in (469) may seem rather large, the reader should note that these are explicit instantiations of only a handful of rule schemata - three, to be precise. With the FreeSVO package, we obtain completely free word order within the domain of a verbal head, as illustrated in the derivations in (470). Languages that display such behavior are for example Czech and Russian, at least in simple cases. I discussed an initial proposal for dealing with a more complex case like Czech clitics in (Kruijff, 1999a).

(470) a.

$$\begin{array}{cl}
\dfrac{\mathrm{subj} \vdash \Box^{\downarrow}{}_{act}n \qquad \dfrac{\dfrac{\mathrm{verb} \vdash \Box^{\downarrow}{}_{vhead}((\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)/_{dc>}\Box^{\downarrow}{}_{pat}n)}{\langle \mathrm{verb}\rangle^{vhead} \vdash (\Box^{\downarrow}{}_{act}n\backslash_{<sc}s)/_{dc>}\Box^{\downarrow}{}_{pat}n}\,[\Box^{\downarrow}E] \qquad \mathrm{dobj} \vdash \Box^{\downarrow}{}_{pat}n}{\langle \mathrm{verb}\rangle^{vhead} \circ_{dc>}\mathrm{dobj} \vdash \Box^{\downarrow}{}_{act}n\backslash_{<sc}s}\,[/E]}{\mathrm{subj} \circ_{<sc}(\langle \mathrm{verb}\rangle^{vhead} \circ_{dc>}\mathrm{dobj}) \vdash s} & [\backslash E] \\
\hline
(\langle \mathrm{verb}\rangle^{vhead} \circ_{sc>}\mathrm{subj}) \circ_{dc>}\mathrm{dobj} \vdash s & [FreeSVO1.m(vhead, sc)] \\
\hline
(\langle \mathrm{verb}\rangle^{free} \circ_{sc>}\mathrm{subj}) \circ_{dc>}\mathrm{dobj} \vdash s & [FreeSVO.l(vhead, free)] \\
\hline
\langle \mathrm{verb} \circ_{sc>}\mathrm{subj}\rangle^{free} \circ_{dc>}\mathrm{dobj} \vdash s & [FreeSVO.p(free, sc)] \\
\hline
\langle (\mathrm{verb} \circ_{sc>}\mathrm{subj}) \circ_{dc>}\mathrm{dobj}\rangle^{free} \vdash s & [FreeSVO.p(free, dc)] \\
\hline
\langle (\mathrm{verb} \circ_{sc>}\mathrm{subj}) \circ_{dc>}\mathrm{dobj}\rangle^{mtx} \vdash s & [Matrix\ is\ free] \\
\hline
(\mathrm{verb} \circ_{sc>}\mathrm{subj}) \circ_{dc>}\mathrm{dobj} \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

b.

$$\begin{array}{cl}
\vdots & \\
\hline
subj \circ_{<sc}(\langle verb\rangle^{vhead} \circ_{dc>}dobj) \vdash s & \\
\hline
dobj \circ_{<dc}(\langle verb\rangle^{vhead} \circ_{sc>}subj) \vdash s & MxSVO4.m(sc, dc) \\
\hline
dobj \circ_{<dc}(\langle verb\rangle^{free} \circ_{sc>}subj) \vdash s & Vhead\ is\ free \\
\hline
dobj \circ_{<dc}\langle (verb \circ_{sc>}subj)\rangle^{free} \vdash s & FreeSVO.p(free, sc) \\
\hline
\langle dobj \circ_{<dc}(verb \circ_{sc>}subj)\rangle^{free} \vdash s & FreeSVO.p(free, dc) \\
\hline
\langle dobj \circ_{<dc}(verb \circ_{sc>}subj)\rangle^{mtx} \vdash s & Mtx\ is\ free \\
\hline
dobj \circ_{<dc}(verb \circ_{sc>}subj) \vdash \Box^{\downarrow}{}_{mtx}s & I\Box^{\downarrow}
\end{array}$$

c.

$$\begin{array}{cl}
\vdots & \\
\hline
subj \circ_{<sc}(\langle verb\rangle^{vhead} \circ_{dc>}dobj) \vdash s & \\
\hline
subj \circ_{<sc}(dobj \circ_{<dc}\langle verb\rangle^{vhead}) \vdash s & FreeSVO.m(vhead, dc) \\
\hline
subj \circ_{<sc}(dobj \circ_{<dc}\langle verb\rangle^{free}) \vdash s & Vhead\ is\ free \\
\hline
dobj \circ_{<dc}(subj \circ_{<sc}\langle verb\rangle^{free}) \vdash s & MxSVO3.m(sc, dc) \\
\hline
dobj \circ_{<dc}\langle (subj \circ_{<sc}verb)\rangle^{free} \vdash s & FreeSVO.p(free, sc) \\
\hline
\langle dobj \circ_{<dc}(subj \circ_{<sc}verb)\rangle^{free} \vdash s & FreeSVO.p(free, dc) \\
\hline
\langle dobj \circ_{<dc}(subj \circ_{<sc}verb)\rangle^{mtx} \vdash s & Mtx\ is\ free \\
\hline
dobj \circ_{<dc}(subj \circ_{<sc}verb) \vdash \Box^{\downarrow}{}_{mtx}s & I\Box^{\downarrow}
\end{array}$$

7.4 MODELING THE STRATEGIES

The hypotheses we formulated in Chapter 6 are best viewed as indicating how *strategies* like word order or tune realize a category of informativity in a particular setting. In this section, we work out the structural rules defining these strategies in more detail. These structural rules extend the basic grammar architectures I developed in the previous section.

The approach to modeling the word order-based strategies to realize information structure is as follows. We already discussed earlier the relation between contextual boundness and the Praguian conception of systemic ordering: wordgroups realizing the contextually nonbound dependents of the focus appear in canonical or systemic ordering. There is no such constraint on wordgroups realizing contextually bound dependents, whose ordering is rather dependent on the underlying scale of communicative dynamism. We also observed the important role that systemic ordering plays in focus projection.

Therefore, the first step we take is to rewrite the grammatical modes *sc*, *dc*, etc. into modes that indicate whether or not the dependents are realized in systemic ordering. We introduce headed modes *so* (systemically ordered) and *ns* (not systemically ordered) to indicate this. The new *so*/*ns*-structure abstracts not only from the particular grammatical structure, but also –more importantly– from a language's specific systemic ordering.[16] This enables to formulate a more general account of word order as a structural indication of informativity. Once we have a structure indicating the (non-)systemic ordering of dependents, we follow the informativity hypotheses of Chapter 6 to determine contextual boundness of the individual wordgroups.

The structural rules modeling word order strategies to realize information structure control the more basic word order rules as follows. The goal category we try to prove states that the (verbal) head of the construction has to have a specific informativity, e.g. $\Box^{\downarrow}{}_{nb}$. The structural rules define how the contextual boundness of the verbal head influences further possible distributions of contextually bound/contextually nonbound values over

---

[16] Languages may show differences in their systemic orderings; only within a single language, its systemic ordering is considered universal, (Sgall et al., 1986; Sgall et al., 1995). The mapping from modes like *sc*, *dc* to so, ns can be made sensitive to a language's specific systemic ordering. However, the resulting *so*/*ns*-structure is independent of that specific systemic ordering, since it is formulated purely in terms of whether or not *some* systemic ordering is obeyed.

the dependents. Whether these distributions are then derivable from the canonical word order depends on the possibilities to vary word order.

Besides being a natural way to go in a dependency grammar, defining the models in terms of systemic ordering rather than specific grammatical structures not only yields a more general perspective – it also provides for a smooth integration with models of tune as a structural indication of informativity, as we show in Chapter 8.

Below we define the fundamental rules for the models, and illustrate them on basic examples relating to the more linguistically oriented discussion in Chapter 5. The definitions only elaborate a simple mapping to *so/ns*-structures, and only consider relatively shallow structures. This is no inherent theoretical problem, as the definitions can be (monotonically) extended to cover more complex structures.

Definition 40 (Structural indications of informativity in OV). *The* *InfOV* *defines the basic structural rules for describing structural indication of informativity in OV languages, given* INFHYP1 *and* INFHYP2*. The* *InfOV* *monotonically extends all the OV packages, and only defines rules that specify feature information. The structural rules of* *InfOV* *are below, without any reference to tune (as we only define tune in the next chapter).*

$$\begin{array}{rcll}
\langle A \circ_{<so} (B \circ_{<so} C)\rangle^{mtx} & \rightarrow & \langle A \circ_{<sc} (B \circ_{<dc} C)\rangle^{mtx} & [InfOV.SysOrd] \\
\langle (A \circ_{<so} B) \circ_{so>} C\rangle^{mtx} & \rightarrow & \langle (A \circ_{<sc} B) \circ_{dc>} C\rangle^{mtx} & [InfOV.SysOrd] \\
\langle (A \circ_{so>} B) \circ_{so>} C\rangle^{mtx} & \rightarrow & \langle (A \circ_{sc>} B) \circ_{dc>} C\rangle^{mtx} & [InfOV.SysOrd] \\
\langle (A \circ_{ns>} B) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle (A \circ_{dc>} B) \circ_{sc>} C\rangle^{mtx} & [InfOV.NonSysOrd] \\
\langle A \circ_{<ns} (B \circ_{<ns} C)\rangle^{mtx} & \rightarrow & \langle A \circ_{<dc} (B \circ_{<sc} C)\rangle^{mtx} & [InfOV.NonSysOrd] \\
\langle A \circ_{<so} (\langle B\rangle^{nb*} \circ_{<so} C)\rangle^{mtx} & \rightarrow & \langle A \circ_{<so} (\langle B\rangle^{inf} \circ_{<so} C)\rangle^{mtx} & [InfOV.ImmPreV.CFP] \\
\langle A \circ_{<ns} (\langle B\rangle^{nb*} \circ_{<ns} C)\rangle^{mtx} & \rightarrow & \langle A \circ_{<ns} (\langle B\rangle^{inf} \circ_{<ns} C)\rangle^{mtx} & [InfOV.ImmPreV.CFP] \\
\langle ((\langle A\rangle^{nb*} \circ_{so>} \langle B\rangle^{cb}) \circ_{so>} C\rangle^{mtx} & \rightarrow & \langle ((\langle A\rangle^{inf} \circ_{so>} \langle B\rangle^{inf}) \circ_{so>} C\rangle^{mtx} & [InfOV.VerbFocus] \\
\langle ((\langle A\rangle^{nb*} \circ_{ns>} \langle B\rangle^{cb}) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle ((\langle A\rangle^{inf} \circ_{ns>} \langle B\rangle^{inf}) \circ_{ns>} C\rangle^{mtx} & [InfOV.VerbFocus] \\
(A \circ_{ns>} \langle B\rangle^{cb}) \circ_{ns>} \langle C\rangle^{cb} & \rightarrow & (A \circ_{ns>} \langle B\rangle^{cb}) \circ_{ns>} \langle C\rangle^{inf} & [InfOV.VerbFocus] \\
\langle (A \circ_{<so} B) \circ_{so>} \langle C\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle (A \circ_{<so} B) \circ_{so>} \langle C\rangle^{inf}\rangle^{mtx} & [InfOV.PostV.FP] \\
\langle A\rangle^{nb*} \circ_{<so} \langle B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<so} \langle B\rangle^{inf} & [InfOV.RwrdFProj] \\
\langle A\rangle^{nb} \circ_{<so} (\langle B\rangle^{nb*} \circ_{<so} C) & \rightarrow & \langle A\rangle^{inf} \circ_{<so} (\langle B\rangle^{nb*} \circ_{<so} C) & [InfOV.LwrdFProj] \\
\langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{cb} & \rightarrow & \langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{cb} & [InfOV.TProj] \\
\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb} & \rightarrow & \langle A\rangle^{inf} \circ_{<ns} \langle B\rangle^{cb} & [InfOV.TProj] \\
(A \circ_{so>} \langle B\rangle^{cb}) \circ_{so>} \langle C\rangle^{cb} & \rightarrow & (A \circ_{so>} \langle B\rangle^{cb}) \circ_{so>} \langle C\rangle^{inf} & [InfOV.TProj] \\
\langle A\rangle^{nb*} \circ_{<so} \langle B\rangle^{cb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<so} \langle B\rangle^{inf} & [InfOV.RwrdTProj] \\
\langle A\rangle^{nb*} \circ_{<ns} \langle B\rangle^{cb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<ns} \langle B\rangle^{inf} & [InfOV.RwrdTProj] \\
\langle A\rangle^{cb} \circ_{<so} (\langle B\rangle^{nb*} \circ_{<so} C) & \rightarrow & \langle A\rangle^{inf} \circ_{<so} (\langle B\rangle^{nb*} \circ_{<so} C) & [InfOV.SOBoundary] \\
(A \circ_{<so} \langle B\rangle^{cb}) \circ_{so>} \langle C\rangle^{nb*} & \rightarrow & (A \circ_{<so} \langle B\rangle^{inf}) \circ_{so>} \langle C\rangle^{nb*} & [InfOV.SOBoundary] \\
\langle \langle A\rangle^{cb} \circ_{<so} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{cb} & [InfOV.p(cb, < so)] \\
\langle A \circ_{so>} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{so>} B & [InfOV.p(cb, so >)] \\
\langle A \circ_{so>} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{so>} B & [InfOV.p(nb, so >)] \\
\langle A \circ_{ns>} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{ns>} B & [InfOV.p(nb, ns >)] \\
\langle A \circ_{ns>} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{ns>} B & [InfOV.p(cb, ns >)] \\
\langle \langle A\rangle^{cb} \circ_{<ns} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb} & [InfOV.p(cb, < ns)] \\
\langle ((\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb}) \circ_{<ns} C\rangle^{nb*} & \rightarrow & ((\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb}) \circ_{<ns} \langle C\rangle^{nb*} & [InfOV.p(nb*, < ns)] \\
\langle \langle A\rangle^{nb*} \circ_{<so} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<so} \langle B\rangle^{nb} & [InfOV.p(nb, < so)] \\
\langle \langle A\rangle^{acc}\rangle^{inf} & \rightarrow & \langle \langle A\rangle^{inf}\rangle^{acc} & [InfOV.p(inf, acc)] \\
\langle \langle A\rangle^{nom}\rangle^{inf} & \rightarrow & \langle \langle A\rangle^{inf}\rangle^{nom} & [InfOV.p(inf, nom)] \\
\langle \langle A\rangle^{cb} \circ_{<so} B\rangle^{nb} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{nb} & [InfOV.p(nb, < so)] \\
\langle \langle A\rangle^{nb} \circ_{<so} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{<so} \langle B\rangle^{nb} & [InfOV.p(nb, < so)]
\end{array}$$

$$\begin{array}{rcll}
\langle A \circ_{so>} \langle B\rangle^{cb}\rangle^{nb*} & \rightarrow & \langle A\rangle^{nb*} \circ_{so>} \langle B\rangle^{cb} & [InfOV.p(nb*, so >)] \\
\langle A \circ_{ns>} \langle B\rangle^{cb}\rangle^{nb*} & \rightarrow & \langle A\rangle^{nb*} \circ_{ns>} \langle B\rangle^{cb} & [InfOV.p(nb*, ns >)] \\
\langle \langle A\rangle^{nb*} \circ_{<ns} B\rangle^{cb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<ns} \langle B\rangle^{cb} & [InfOV.p(cb, < ns)] \\
\langle \langle A\rangle^{nb*} \circ_{<so} B\rangle^{cb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<so} \langle B\rangle^{cb} & [InfOV.p(cb, < so)]
\end{array}$$

$\circledast$

Remark 37 (Explanation of the InfOV package). To begin with, the InfOV package as we define it above does not have explicit reference to tune yet. The reason being that we only deal with the modeling of tune in the next chapter. Thus, so far we only capture the effect of word order.

The strategy employed in the InfOV package is rather straightforward. The goal category should specify the informativity of the verbal head. Technically, what we do then is that we first assign the focus proper (nb*), and subsequently distribute cb and nb features as appropriate to the construction (word order) we have. We need to end up with a distribution that assigns the verbal head a contextual boundness as required by the goal category.

To that end, we specify percolation rules that distribute features (the p(X,Y) rules), and linkage rules that specify features. The ImmPreV.CFP rules realize the focus proper in the canonical focus position, being immediately before the verb. The PostV.FP rule covers the case of a postverbally realized focus proper, as possible in non-rigid verb-final languages like Sinhala (Herring and Paolillo, 1995). The VerbFocus rules cover cases observable in free OV languages like Turkish, Hungarian and Hindi where the verb forms the focus proper if there is no preverbally placed dependent. Once we have established the focus proper, we can project the topic (TProj) and the focus (FProj).

From a more linguistic perspective, we should read a proof bottom-up. At the bottom, we find a sentence with given indications of informativity. Then, reading upwards, we see how the sentence's information structure determines its actual word order, as we reason how the observed word order can be established on the basis of the canonical word order - a view akin to the generative perspective taken in FGD, cf. Sgall et al's discussion in (1986) and Petkevič (in prep).

Example. First, let us consider various unmarked cases, where the focus proper is realized in the immediately preverbal position. The proof in (471) shows the realization of an "out-of-the-blue" sentence.

(471)
$$\begin{array}{c l}
\vdots & \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{inf} \circ <_{sc}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{inf} \circ <_{dc}\langle\text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{inf} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{inf} \circ <_{so}\langle\text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.SysOrd] \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{inf} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\langle\text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.ImmPreV.CFP] \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{inf} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\langle\text{tverbi}\rangle^{nb}))\rangle^{mtx} \vdash s & [InfOV.RwrdFProj] \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{nb} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\langle\text{tverbi}\rangle^{nb}))\rangle^{mtx} \vdash s & [InfOV.LwrdFProj] \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{nb} \circ <_{so}\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\text{tverbi}\rangle^{nb}\rangle^{mtx} \vdash s & [InfOV.p(nb, < so)] \\ \hline
\langle\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{nb} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\text{tverbi}))\rangle^{nb}\rangle^{mtx} \vdash s & [InfOV.p(nb, < so)] \\ \hline
\langle\langle\langle\text{subjci}\rangle^{nom}\rangle^{nb} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\text{tverbi}))\rangle^{nb} \vdash \Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I] \\ \hline
\langle\langle\text{subjci}\rangle^{nom}\rangle^{nb} \circ <_{so}(\langle\langle\langle\text{dobjci}\rangle^{acc}\rangle^{nb*} \circ <_{so}\text{tverbi}) \vdash \Box^{\downarrow}{}_{nb}\Box^{\downarrow}{}_{mtx}s & [\Box^{\downarrow}I]
\end{array}$$

The next examples shows how we can realize a narrow focus, being constituted by just the focus proper (472), or a wider focus including more dependents, (473).

(472)

$$\begin{array}{cl}
\vdots & \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<sc} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{inf} \circ_{<dc} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{inf} \circ_{<so} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.SysOrd] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.ImmPreV.CFP] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.SOBoundary] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \langle \text{tverbi}\rangle^{cb}))\rangle^{mtx} \vdash s & [InfOV.RwrdTProj] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \circ_{<so} \langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(cb, < so)] \\ \cline{1-1}
\langle\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}))\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(cb, < so)] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}))\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \cline{1-1}
\langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \circ_{<so} (\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}) \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

(473)

$$\begin{array}{cl}
\vdots & \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<sc} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{inf} \circ_{<dc} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{inf} \circ_{<so} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.SysOrd] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \langle \text{tverbi}\rangle^{inf}))\rangle^{mtx} \vdash s & [InfOV.ImmPreV.CFP] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{inf} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \langle \text{tverbi}\rangle^{cb}))\rangle^{mtx} \vdash s & [InfOV.RwrdTProj] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{nb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \langle \text{tverbi}\rangle^{cb}))\rangle^{mtx} \vdash s & [InfOV.LwrdFProj] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{nb} \circ_{<so} \langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(cb, < so)] \\ \cline{1-1}
\langle\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{nb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}))\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(cb, < so)] \\ \cline{1-1}
\langle\langle\langle \text{subjci}\rangle^{nom}\rangle^{nb} \circ_{<so} (\langle\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}))\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \cline{1-1}
\langle\langle \text{subjci}\rangle^{nom}\rangle^{nb} \circ_{<so} (\langle\langle \text{dobjci}\rangle^{acc}\rangle^{nb*} \circ_{<so} \text{tverbi}) \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

⊛

Example. The structural rules in InfVO also allow for more marked cases, obtainable through word order alone. For example, we can realize just the verb as focus by placing it sentence-initially. We can observe this behavior in for example Hungarian (Vallduví and Engdahl, 1996) or Turkish (Hoffman, 1995a). Examples (474) and (475) differ in the order in which the dependents are realized.

(474)

$$\begin{array}{cl}
\vdots & \\ \cline{1-1}
\langle(\langle \text{tverbi}\rangle^{inf} \circ_{dc>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{inf}) \circ_{sc>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{inf}\rangle^{mtx} \vdash s & \\ \cline{1-1}
\langle(\langle \text{tverbi}\rangle^{inf} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{inf}) \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{inf}\rangle^{mtx} \vdash s & [InfOV.NonSysOrd] \\ \cline{1-1}
\langle(\langle \text{tverbi}\rangle^{nb*} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{inf}\rangle^{mtx} \vdash s & [InfOV.VerbFocus] \\ \cline{1-1}
\langle(\langle \text{tverbi}\rangle^{nb*} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.VerbFocus] \\ \cline{1-1}
\langle\langle \text{tverbi} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{cb}\rangle^{nb*} \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(nb*, ns >)] \\ \cline{1-1}
\langle\langle(\text{tverbi} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{cb}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfOV.p(nb*, ns >)] \\ \cline{1-1}
\langle(\text{tverbi} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{cb}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \cline{1-1}
(\text{tverbi} \circ_{ns>} \langle\langle \text{dobjci}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subjci}\rangle^{nom}\rangle^{cb} \vdash \Box^{\downarrow}{}_{nb*}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

(475)

$$
\begin{array}{cl}
\vdots & \\ \hline
\langle((\langle \mathrm{tverbi}\rangle^{inf} \circ {}_{sc>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf}) \circ {}_{dc>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{inf}\rangle^{mtx} \vdash s & \\ \hline
\langle((\langle \mathrm{tverbi}\rangle^{inf} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{inf}\rangle^{mtx} \vdash s & [InfOV.SysOrd] \\ \hline
\langle((\langle \mathrm{tverbi}\rangle^{nb*} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{inf}\rangle^{mtx} \vdash s & [InfOV.VerbFocus] \\ \hline
\langle((\langle \mathrm{tverbi}\rangle^{nb*} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.TProj] \\ \hline
\langle\langle \mathrm{tverbi} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb}\rangle^{nb*} \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(nb*, so>)] \\ \hline
\langle\langle(\mathrm{tverbi} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{cb}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfOV.p(nb*, so>)] \\ \hline
\langle(\mathrm{tverbi} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{cb}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\mathrm{tverbi} \circ {}_{so>}\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{cb} \vdash \Box^{\downarrow}{}_{nb*}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

Finally, consider the post-verbally realized focus proper in (476). We illustrated such constructions in Chapter 6 on Sinhala, a non-rigid verb-final language.

(476)

$$
\begin{array}{cl}
\vdots & \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{inf}\rangle^{nom} \circ {}_{<sc}\langle \mathrm{tverbi}\rangle^{inf}) \circ {}_{dc>}\langle\langle \mathrm{dobjci}\rangle^{inf}\rangle^{acc}\rangle^{mtx} \vdash s & \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf} \circ {}_{<sc}\langle \mathrm{tverbi}\rangle^{inf}) \circ {}_{dc>}\langle\langle \mathrm{dobjci}\rangle^{inf}\rangle^{acc}\rangle^{mtx} \vdash s & [InfOV.p(inf, nom)] \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf} \circ {}_{<sc}\langle \mathrm{tverbi}\rangle^{inf}) \circ {}_{dc>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{inf}\rangle^{mtx} \vdash s & [InfOV.p(inf, acc)] \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf} \circ {}_{<so}\langle \mathrm{tverbi}\rangle^{inf}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{inf}\rangle^{mtx} \vdash s & [InfOV.SysOrd] \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf} \circ {}_{<so}\langle \mathrm{tverbi}\rangle^{inf}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfOV.PostV.FP] \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{inf} \circ {}_{<so}\langle \mathrm{tverbi}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfOV.SOBoundary] \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb} \circ {}_{<so}\langle \mathrm{tverbi}\rangle^{cb}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfOV.TProj] \\ \hline
\langle\langle\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb} \circ {}_{<so}\mathrm{tverbi}\rangle^{cb} \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfOV.p(cb, <so)] \\ \hline
\langle\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb} \circ {}_{<so}\mathrm{tverbi}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*}\rangle^{cb}\rangle^{mtx} \vdash s & [InfOV.p(cb, so>)] \\ \hline
\langle((\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb} \circ {}_{<so}\mathrm{tverbi}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\langle\langle \mathrm{subjci}\rangle^{nom}\rangle^{cb} \circ {}_{<so}\mathrm{tverbi}) \circ {}_{so>}\langle\langle \mathrm{dobjci}\rangle^{acc}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

⊛

Definition 41 (Structural indications of informativity in VO). *The InfVO defines the basic structural rules for describing structural indication of informativity in VO languages, given* INFHYP1 *and* INFHYP2*. The InfVO monotonically extends all the VO packages, and only defines rules that specify feature information. The basic set of structural rules of InfVO is given below, without any reference to tune. Because of lack of sufficient data, as we indicated already in Chapter 6, the InfVO is smaller than the InfOV and InfSVO packages.*

$$
\begin{array}{rcll}
\langle (A \circ_{so>} B) \circ_{so>} C \rangle^{mtx} & \rightarrow & \langle (A \circ_{sc>} B) \circ_{dc>} C \rangle^{mtx} & [InfVO.SysOrd] \\
\langle (A \circ_{<so} B) \circ_{so>} C \rangle^{mtx} & \rightarrow & \langle A \circ_{<sc} (B \circ_{dc>} C) \rangle^{mtx} & [InfVO.SysOrd] \\
\langle (A \circ_{<ns} B) \circ_{ns>} C \rangle^{mtx} & \rightarrow & \langle A \circ_{<dc} (B \circ_{sc>} C) \rangle^{mtx} & [InfVO.NonSysOrd] \\
\langle (A \circ_{ns>} B) \circ_{ns>} C \rangle^{mtx} & \rightarrow & \langle (A \circ_{dc>} B) \circ_{sc>} C \rangle^{mtx} & [InfVO.NonSysOrd] \\
\langle A \circ_{so>} \langle B \rangle^{nb*} \rangle^{mtx} & \rightarrow & \langle A \circ_{so>} \langle B \rangle^{inf} \rangle^{mtx} & [InfVO.PostV.CFP] \\
\langle A \circ_{ns>} \langle B \rangle^{nb*} \rangle^{mtx} & \rightarrow & \langle A \circ_{ns>} \langle B \rangle^{inf} \rangle^{mtx} & [InfVO.PostV.CFP] \\
(A \circ_{so>} \langle B \rangle^{nb}) \circ_{so>} \langle C \rangle^{nb*} & \rightarrow & (A \circ_{so>} \langle B \rangle^{inf}) \circ_{so>} \langle C \rangle^{nb*} & [InfVO.FProj] \\
\langle A \rangle^{nb} \circ_{so>} \langle B \rangle^{nb} & \rightarrow & \langle A \rangle^{inf} \circ_{so>} \langle B \rangle^{nb} & [InfVO.FProj] \\
\langle A \rangle^{cb} \circ_{ns>} \langle B \rangle^{cb} & \rightarrow & \langle A \rangle^{inf} \circ_{ns>} \langle B \rangle^{cb} & [InfVO.TProj] \\
\langle A \rangle^{cb} \circ_{<ns} \langle B \rangle^{cb} & \rightarrow & \langle A \rangle^{inf} \circ_{<ns} \langle B \rangle^{cb} & [InfVO.TProj] \\
\langle A \rangle^{cb} \circ_{so>} \langle B \rangle^{nb} & \rightarrow & \langle A \rangle^{inf} \circ_{so>} \langle B \rangle^{nb} & [InfVO.SOBoundary] \\
(A \circ_{<ns} \langle B \rangle^{cb}) \circ_{ns>} \langle C \rangle^{nb*} & \rightarrow & (A \circ_{<ns} \langle B \rangle^{inf}) \circ_{ns>} \langle C \rangle^{nb*} & [InfVO.NSOBoundary] \\
(A \circ_{ns>} \langle B \rangle^{cb}) \circ_{ns>} \langle C \rangle^{nb*} & \rightarrow & (A \circ_{ns>} \langle B \rangle^{inf}) \circ_{ns>} \langle C \rangle^{nb*} & [InfVO.NSOBoundary] \\
(\langle A \rangle^{cb} \circ_{<so} \langle B \rangle^{cb}) \circ_{so>} \langle C \rangle^{nb*} & \rightarrow & (\langle A \rangle^{inf} \circ_{<so} \langle B \rangle^{inf}) \circ_{so>} \langle C \rangle^{nb*} & [InfVO.PreVerb.Boundary] \\
(\langle A \rangle^{cb} \circ_{<so} \langle B \rangle^{nb}) \circ_{so>} \langle C \rangle^{nb*} & \rightarrow & (\langle A \rangle^{inf} \circ_{<so} \langle B \rangle^{inf}) \circ_{so>} \langle C \rangle^{nb*} & [InfVO.PreVerb.Boundary] \\
\langle A \circ_{so>} B \rangle^{nb} & \rightarrow & \langle A \rangle^{nb} \circ_{so>} B & [InfVO.p(nb, so >)] \\
\langle \langle A \rangle^{acc} \rangle^{inf} & \rightarrow & \langle \langle A \rangle^{inf} \rangle^{acc} & [InfVO.p(inf, acc)] \\
\langle \langle A \rangle^{nom} \rangle^{inf} & \rightarrow & \langle \langle A \rangle^{inf} \rangle^{nom} & [InfVO.p(inf, nom)] \\
\langle \langle A \rangle^{cb} \circ_{<ns} B \rangle^{cb} & \rightarrow & \langle A \rangle^{cb} \circ_{<ns} \langle B \rangle^{cb} & [InfVO.p(cb, < ns)] \\
\langle A \circ_{ns>} B \rangle^{cb} & \rightarrow & \langle A \rangle^{cb} \circ_{ns>} B & [InfVO.p(cb, ns >)] \\
\langle A \circ_{so>} B \rangle^{cb} & \rightarrow & \langle A \rangle^{cb} \circ_{so>} B & [InfVO.p(cb, so >)] \\
\langle \langle A \rangle^{cb} \circ_{<so} B \rangle^{cb} & \rightarrow & \langle A \rangle^{cb} \circ_{<so} \langle B \rangle^{cb} & [InfVO.p(cb, < so)] \\
\langle \langle A \rangle^{cb} \circ_{<so} B \rangle^{nb} & \rightarrow & \langle A \rangle^{cb} \circ_{<so} \langle B \rangle^{nb} & [InfVO.p(nb, < so)]
\end{array}
$$

⊛

Example (VO realization of information structure). We give three brief examples - canonical word order (477), noncanonical word order (478), and non-rigid verb-firstness (479).

(477)

$$
\begin{array}{cl}
\vdots & \\ \hline
\langle ((\langle \text{tverbi} \rangle^{inf} \circ_{sc>} \langle \langle \text{subji} \rangle^{nom} \rangle^{inf}) \circ_{dc>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{inf} \rangle^{mtx} \vdash s & \\ \hline
\langle ((\langle \text{tverbi} \rangle^{inf} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{inf}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{inf} \rangle^{mtx} \vdash s & [InfVO.SysOrd] \\ \hline
\langle ((\langle \text{tverbi} \rangle^{inf} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{inf}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \rangle^{mtx} \vdash s & [InfVO.PostV.CFP] \\ \hline
\langle ((\langle \text{tverbi} \rangle^{inf} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{nb}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \rangle^{mtx} \vdash s & [InfVO.FProj] \\ \hline
\langle ((\langle \text{tverbi} \rangle^{nb} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{nb}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \rangle^{mtx} \vdash s & [InfVO.FProj] \\ \hline
\langle \langle \text{tverbi} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{nb} \rangle^{nb} \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \rangle^{mtx} \vdash s & [InfVO.p(nb, so >)] \\ \hline
\langle \langle (\text{tverbi} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{nb}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \rangle^{nb} \rangle^{mtx} \vdash s & [InfVO.p(nb, so >)] \\ \hline
\langle (\text{tverbi} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{nb}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \rangle^{nb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\text{tverbi} \circ_{so>} \langle \langle \text{subji} \rangle^{nom} \rangle^{nb}) \circ_{so>} \langle \langle \text{dobji} \rangle^{acc} \rangle^{nb*} \vdash \Box^{\downarrow}{}_{nb} \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

(478)
$$
\begin{array}{cl}
\vdots & \\
\hline
\langle((\langle \text{tverbi}\rangle^{inf} \circ_{dc>} \langle\langle \text{dobji}\rangle^{inf}\rangle^{acc}) \circ_{sc>} \langle\langle \text{subji}\rangle^{inf}\rangle^{nom}\rangle^{mtx} \vdash s & \\
\hline
\langle((\langle \text{tverbi}\rangle^{inf} \circ_{ns>} \langle\langle \text{dobji}\rangle^{inf}\rangle^{acc}) \circ_{ns>} \langle\langle \text{subji}\rangle^{inf}\rangle^{nom}\rangle^{mtx} \vdash s & [InfVO.NonSysOrd] \\
\hline
\langle((\langle \text{tverbi}\rangle^{inf} \circ_{ns>} \langle\langle \text{dobji}\rangle^{inf}\rangle^{acc}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{inf}\rangle^{mtx} \vdash s & [InfVO.p(inf, nom)] \\
\hline
\langle((\langle \text{tverbi}\rangle^{inf} \circ_{ns>} \langle\langle \text{dobji}\rangle^{inf}\rangle^{acc}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.PostV.CFP] \\
\hline
\langle((\langle \text{tverbi}\rangle^{inf} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{inf}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.p(inf, acc)] \\
\hline
\langle((\langle \text{tverbi}\rangle^{inf} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.NSOBoundary] \\
\hline
\langle((\langle \text{tverbi}\rangle^{cb} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.TProj] \\
\hline
\langle\langle \text{tverbi} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{cb}\rangle^{cb} \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.p(cb, ns>)] \\
\hline
\langle\langle(\text{tverbi} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{cb}\rangle^{mtx} \vdash s & [InfVO.p(cb, ns>)] \\
\hline
\langle(\text{tverbi} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\
\hline
(\text{tverbi} \circ_{ns>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{cb}) \circ_{ns>} \langle\langle \text{subji}\rangle^{nom}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{cb} \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

(479)
$$
\begin{array}{cl}
\vdots & \\
\hline
\langle\langle\langle \text{subji}\rangle^{inf}\rangle^{nom} \circ_{<sc} (\langle \text{tverbi}\rangle^{inf} \circ_{dc>} \langle\langle \text{dobji}\rangle^{inf}\rangle^{acc})\rangle^{mtx} \vdash s & [Matrix\ is\ non-rigid\ vfirst] \\
\hline
\langle\langle\langle \text{subji}\rangle^{nom}\rangle^{inf} \circ_{<sc} (\langle \text{tverbi}\rangle^{inf} \circ_{dc>} \langle\langle \text{dobji}\rangle^{inf}\rangle^{acc})\rangle^{mtx} \vdash s & [InfVO.p(inf, nom)] \\
\hline
\langle\langle\langle \text{subji}\rangle^{nom}\rangle^{inf} \circ_{<sc} (\langle \text{tverbi}\rangle^{inf} \circ_{dc>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{inf})\rangle^{mtx} \vdash s & [InfVO.p(inf, acc)] \\
\hline
\langle((\langle\langle \text{subji}\rangle^{nom}\rangle^{inf} \circ_{<so} \langle \text{tverbi}\rangle^{inf}) \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{inf}\rangle^{mtx} \vdash s & [InfVO.SysOrd] \\
\hline
\langle((\langle\langle \text{subji}\rangle^{nom}\rangle^{inf} \circ_{<so} \langle \text{tverbi}\rangle^{inf}) \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.PostV.CFP] \\
\hline
\langle((\langle\langle \text{subji}\rangle^{nom}\rangle^{cb} \circ_{<so} \langle \text{tverbi}\rangle^{cb}) \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.PreVerb.Boundary] \\
\hline
\langle\langle\langle\langle \text{subji}\rangle^{nom}\rangle^{cb} \circ_{<so} \text{tverbi}\rangle^{cb} \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfVO.p(cb, <so)] \\
\hline
\langle\langle((\langle\langle \text{subji}\rangle^{nom}\rangle^{cb} \circ_{<so} \text{tverbi}) \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{nb*}\rangle^{cb}\rangle^{mtx} \vdash s & [InfVO.p(cb, so>)] \\
\hline
\langle((\langle\langle \text{subji}\rangle^{nom}\rangle^{cb} \circ_{<so} \text{tverbi}) \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{nb*}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\
\hline
((\langle\langle \text{subji}\rangle^{nom}\rangle^{cb} \circ_{<so} \text{tverbi}) \circ_{so>} \langle\langle \text{dobji}\rangle^{acc}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{cb} \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

$\circledast$

Definition 42 (Structural indications of informativity in SVO). *The InfSVO defines the basic structural rules for describing structural indication of informativity in SVO languages, given* InfHyp1 *and* InfHyp2*. The InfSVO monotonically extends all the SVO packages, and only defines rules that specify feature information. The basic set of structural rules of InfSVO is given below, without any reference to tune. The strategy followed is the same as in the previous packages, except that we pay more attention here to the relation between non-systemic ordering and the boundary between (the realizations of) topic and focus.*

$$
\begin{array}{rcll}
\langle A \circ_{<so} B\rangle^{mtx} & \rightarrow & \langle A \circ_{<sc} B\rangle^{mtx} & [InfSVO.SysOrd] \\
\langle (A \circ_{<so} B) \circ_{so>} C\rangle^{mtx} & \rightarrow & \langle A \circ_{<so} (B \circ_{dc>} C)\rangle^{mtx} & [InfSVO.SysOrd] \\
(A \circ_{so>} B) \circ_{so>} C & \rightarrow & (A \circ_{ic>} B) \circ_{dc>} C & [InfSVO.SysOrd] \\
\langle A \circ_{<ns} B\rangle^{mtx} & \rightarrow & \langle A \circ_{<dc} B\rangle^{mtx} & [InfSVO.NonSysOrd] \\
\langle A \circ_{<ns} B\rangle^{mtx} & \rightarrow & \langle A \circ_{<ic} B\rangle^{mtx} & [InfSVO.NonSysOrd] \\
\langle (A \circ_{<ns} B) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle A \circ_{<ns} (B \circ_{sc>} C)\rangle^{mtx} & [InfSVO.NonSysOrd] \\
\langle (A \circ_{<ns} B) \circ_{<ns} C\rangle^{mtx} & \rightarrow & \langle A \circ_{<sc} (B \circ_{<dc} C)\rangle^{mtx} & [InfSVO.NonSysOrd] \\
\langle (A \circ_{<ns} B) \circ_{<ns} C\rangle^{mtx} & \rightarrow & \langle A \circ_{<dc} (B \circ_{<sc} C)\rangle^{mtx} & [InfSVO.NonSysOrd] \\
\langle (A \circ_{ns>} B) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle (A \circ_{dc>} B) \circ_{sc>} C\rangle^{mtx} & [InfSVO.NonSysOrd]
\end{array}
$$

$$\begin{array}{rcll}
\langle A \circ_{so>} \langle B\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle A \circ_{so>} \langle B\rangle^{inf}\rangle^{mtx} & [InfSVO.PostV.CFP] \\
\langle A \circ_{ns>} \langle B\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle A \circ_{ns>} \langle B\rangle^{inf}\rangle^{mtx} & [InfSVO.PostV.CFP] \\
\langle A \circ_{<ns} \langle B\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle A \circ_{<ns} \langle B\rangle^{inf}\rangle^{mtx} & [InfSVO.PostV.CFP] \\
(\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{nb}) \circ_{so>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{inf}) \circ_{so>} \langle C\rangle^{nb*} & [InfSVO.FProj] \\
(\langle A\rangle^{nb} \circ_{<so} \langle B\rangle^{nb}) \circ_{so>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{inf}) \circ_{so>} \langle C\rangle^{nb*} & [InfSVO.FProj] \\
(\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{cb}) \circ_{so>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{inf}) \circ_{so>} \langle C\rangle^{nb*} & [InfSVO.SOBoundary] \\
(\langle A\rangle^{cb} \circ_{ns>} \langle B\rangle^{cb}) \circ_{ns>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{ns>} \langle B\rangle^{inf}) \circ_{ns>} \langle C\rangle^{nb*} & [InfSVO.NSOBoundary] \\
(\langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{cb}) \circ_{ns>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{inf}) \circ_{ns>} \langle C\rangle^{nb*} & [InfSVO.NSOBoundary] \\
(\langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{nb}) \circ_{ns>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{inf}) \circ_{ns>} \langle C\rangle^{nb*} & [InfSVO.NSOBoundary] \\
(\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb}) \circ_{ns>} \langle C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{inf} \circ_{<ns} \langle B\rangle^{inf}) \circ_{ns>} \langle C\rangle^{nb*} & [InfSVO.NSOBoundary] \\
(A \circ_{<ns} \langle B\rangle^{cb}) \circ_{<ns} \langle C\rangle^{nb*} & \rightarrow & (A \circ_{<ns} \langle B\rangle^{inf}) \circ_{<ns} \langle C\rangle^{nb*} & [InfSVO.NSOBoundary] \\
\langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{cb} & \rightarrow & \langle A\rangle^{inf} \circ_{<so} \langle B\rangle^{cb} & [InfSVO.TProj] \\
\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb} & \rightarrow & \langle A\rangle^{inf} \circ_{<ns} \langle B\rangle^{cb} & [InfSVO.TProj] \\
\langle\langle A\rangle^{cb} \circ_{<so} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{cb} & [InfSVO.p(cb, < so)] \\
\langle A \circ_{so>} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{so>} B & [InfSVO.p(cb, so >)] \\
\langle\langle A\rangle^{cb} \circ_{<so} B\rangle^{nb} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle B\rangle^{nb} & [InfSVO.p(nb, < so)] \\
\langle\langle A\rangle^{nb} \circ_{<so} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{<so} \langle B\rangle^{nb} & [InfSVO.p(nb, < so)] \\
\langle A \circ_{so>} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{so>} B & [InfSVO.p(nb, so >)] \\
\langle A \circ_{ns>} B\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{ns>} B & [InfSVO.p(nb, ns >)] \\
\langle A \circ_{ns>} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{ns>} B & [InfSVO.p(cb, ns >)] \\
\langle\langle A\rangle^{cb} \circ_{<ns} B\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb} & [InfSVO.p(cb, < ns)] \\
\langle((\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb}) \circ_{<ns} C\rangle^{nb*} & \rightarrow & (\langle A\rangle^{cb} \circ_{<ns} \langle B\rangle^{cb}) \circ_{<ns} \langle C\rangle^{nb*} & [InfSVO.p(nb*, < ns)]
\end{array}$$

⊛

Example. To round off this chapter, we present a few examples of the realization of information structure in SVO word order languages. In the next chapter we see more examples of information structure in SVO languages, using a mixture of tune and word order. (480) proves the realization of an "out-of-the-blue" sentence, whereas (481) and (482) illustrate how systemic ordering plays a role in establishing a boundary between topic and focus.

(480)

$$\begin{array}{cl}
\vdots & \\ \hline
\langle\langle \text{subji}\rangle^{inf} \circ_{<sc} (\langle \text{verbi}\rangle^{inf} \circ_{dc>} \langle \text{dobji}\rangle^{inf})\rangle^{mtx} \vdash s & \\ \hline
\langle\langle \text{subji}\rangle^{inf} \circ_{<so} (\langle \text{verbi}\rangle^{inf} \circ_{dc>} \langle \text{dobji}\rangle^{inf})\rangle^{mtx} \vdash s & [InfSVO.SysOrd] \\ \hline
\langle(\langle \text{subji}\rangle^{inf} \circ_{<so} \langle \text{verbi}\rangle^{inf}) \circ_{so>} \langle \text{dobji}\rangle^{inf}\rangle^{mtx} \vdash s & [InfSVO.SysOrd] \\ \hline
\langle(\langle \text{subji}\rangle^{inf} \circ_{<so} \langle \text{verbi}\rangle^{inf}) \circ_{so>} \langle \text{dobji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.PostV.CFP] \\ \hline
\langle(\langle \text{subji}\rangle^{nb} \circ_{<so} \langle \text{verbi}\rangle^{nb}) \circ_{so>} \langle \text{dobji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.FProj] \\ \hline
\langle\langle\langle \text{subji}\rangle^{nb} \circ_{<so} \text{verbi}\rangle^{nb} \circ_{so>} \langle \text{dobji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.p(nb, < so)] \\ \hline
\langle\langle(\langle \text{subji}\rangle^{nb} \circ_{<so} \text{verbi}) \circ_{so>} \langle \text{dobji}\rangle^{nb*}\rangle^{nb}\rangle^{mtx} \vdash s & [InfSVO.p(nb, so >)] \\ \hline
\langle(\langle \text{subji}\rangle^{nb} \circ_{<so} \text{verbi}) \circ_{so>} \langle \text{dobji}\rangle^{nb*}\rangle^{nb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\langle \text{subji}\rangle^{nb} \circ_{<so} \text{verbi}) \circ_{so>} \langle \text{dobji}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{nb} \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

$$(481)\qquad \begin{array}{cl}
\vdots & \\ \hline
\langle\langle\text{dobji}\rangle^{inf} \circ_{<dc}(\langle\text{verbi}\rangle^{inf} \circ_{sc>} \langle\text{subji}\rangle^{inf}))^{mtx} \vdash s & \\ \hline
\langle\langle\text{dobji}\rangle^{inf} \circ_{<ns}(\langle\text{verbi}\rangle^{inf} \circ_{sc>} \langle\text{subji}\rangle^{inf}))^{mtx} \vdash s & [InfSVO.NonSysOrd] \\ \hline
\langle(\langle\text{dobji}\rangle^{inf} \circ_{<ns} \langle\text{verbi}\rangle^{inf}) \circ_{ns>} \langle\text{subji}\rangle^{inf}\rangle^{mtx} \vdash s & [InfSVO.NonSysOrd] \\ \hline
\langle(\langle\text{dobji}\rangle^{inf} \circ_{<ns} \langle\text{verbi}\rangle^{inf}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.PostV.CFP] \\ \hline
\langle(\langle\text{dobji}\rangle^{cb} \circ_{<ns} \langle\text{verbi}\rangle^{cb}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.NSOBoundary] \\ \hline
\langle\langle\langle\text{dobji}\rangle^{cb} \circ_{<ns} \text{verbi}\rangle^{cb} \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.p(cb, < ns)] \\ \hline
\langle\langle(\langle\text{dobji}\rangle^{cb} \circ_{<ns} \text{verbi}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{cb}\rangle^{mtx} \vdash s & [InfSVO.p(cb, ns >)] \\ \hline
\langle(\langle\text{dobji}\rangle^{cb} \circ_{<ns} \text{verbi}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\langle\text{dobji}\rangle^{cb} \circ_{<ns} \text{verbi}) \circ_{ns>} \langle\text{subji}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

$$(482)\qquad \begin{array}{cl}
\vdots & \\ \hline
\langle(\langle\text{verbi}\rangle^{inf} \circ_{dc>} \langle\text{dobji}\rangle^{inf}) \circ_{sc>} \langle\text{subji}\rangle^{inf}\rangle^{mtx} \vdash s & \\ \hline
\langle(\langle\text{verbi}\rangle^{inf} \circ_{ns>} \langle\text{dobji}\rangle^{inf}) \circ_{ns>} \langle\text{subji}\rangle^{inf}\rangle^{mtx} \vdash s & [InfSVO.NonSysOrd] \\ \hline
\langle(\langle\text{verbi}\rangle^{inf} \circ_{ns>} \langle\text{dobji}\rangle^{inf}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.PostV.CFP] \\ \hline
\langle(\langle\text{verbi}\rangle^{cb} \circ_{ns>} \langle\text{dobji}\rangle^{cb}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.NSOBoundary] \\ \hline
\langle\langle\text{verbi} \circ_{ns>} \langle\text{dobji}\rangle^{cb}\rangle^{cb} \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{mtx} \vdash s & [InfSVO.p(cb, ns >)] \\ \hline
\langle\langle(\text{verbi} \circ_{ns>} \langle\text{dobji}\rangle^{cb}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{cb}\rangle^{mtx} \vdash s & [InfSVO.p(cb, ns >)] \\ \hline
\langle(\text{verbi} \circ_{ns>} \langle\text{dobji}\rangle^{cb}) \circ_{ns>} \langle\text{subji}\rangle^{nb*}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\text{verbi} \circ_{ns>} \langle\text{dobji}\rangle^{cb}) \circ_{ns>} \langle\text{subji}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

⊛

SUMMARY

In this chapter I discussed various approaches to modeling word order in a categorial grammar - CCG, MCCG, Set-CCG, and categorial type logic. I elaborated on why we choose for viewing adjacency as a parameter rather than a principle. The "principle"-view yields (in contemporary formulations of CCG) various technical consequences that are at odds with our linguistic intuitions, like the dissociation between the explanations of word order and information structure in MCCG. The "parameter"-view enables us to consider information structure as a primary factor (parameter) determining word order. I presented grammar architectures that formalized the basic aspects of rigid, mixed and free word order predicted by the variation hypotheses of Chapter 6, including complex phenomena like (discontinuous) cross-serial dependencies and nested dependencies. Subsequently, I extended these architectures with models of how word order principally acts as a structural indication of informativity in OV, VO, and SVO, as far as covered by the informativity hypotheses of Chapter 6. The adopted strategy was to relate the syntactic modes to modes that just show whether or not systemic ordering is adhered to, after (Sgall et al., 1986). This provides us not only with a very general description of the relation between word order and information structure. It will also enable us to describe the interaction between tune and word order in a straightforward way, as we shall see in the next chapter. There, we extend the SVO model to cover tune as a structural indication of informativity.

CHAPTER 8

A FORMAL MODEL OF TUNE AS STRUCTURAL INDICATION OF INFORMATIVITY

Besides word order languages usually also use tune to realize information structure - sometimes even predominantly so, like in the case of English. In this chapter, we begin by discussing Steedman's model of English tune developed in Combinatory Categorial Grammar. We then continue by presenting a more abstract model of tune that can be instantiated to cover different languages, and that overcomes a few problems we may note for Steedman's proposal. The chapter ends with a discussion of how to include tune in the model of informativity we developed in the previous chapter.

8.1 INTRODUCTION

The goal of this chapter is to develop an abstract model of tune in its role as a structural indication of informativity, after (Steedman, 2000a), and show how the model can be integrated with the word order account presented in the previous chapter. The integrated architecture enables us to describe formally how tune and word order interact to realize information structure.

Most languages that do not have a mixed or free word order predominantly use tune to realize structural indication of informativity, cf. (372) on page 211. An often-cited example of such a language is English. Only in (very) marked cases does English use both word order and tune - otherwise it just places the nuclear stress in a position other than the unmarked one to realize a different focus. The examples in (483) illustrate this use of tune, on narrow focus.

(483) **English**

a. Elijah gave a book [to KATHY $]_F$.

b. Elijah gave [a BOOK $]_F$ to kath.

c. [ELIJAH $]_F$ gave a book to Kathy.

The use of tune to realize information structure was studied already by Mathesius in the early nineteen thirties - see for example (1975), where Mathesius contrasts English and German. Sgall *et al.* (1986) discuss English tune and how it can be understood to indicate the underlying linguistic meaning's topic-focus articulation, a discussion continued in Hajičová et al's (1998).

An important, recent contribution to the study of tune and its relation to information structure is Pierrehumbert & Hirschberg (1990). Pierrehumbert & Hirschberg argue that the interpretation of tune is built compositionally from *pitch accents*, *phrase accents*, and *boundary tones*.

Various authors have advanced proposals that formalize this compositional interpretation in more detail, including Steedman (2000c; 2000a) and Hendriks (1996; 1997; 1999). Both work out models that are phrased in categorial grammar, with Steedman working in CCG and Hendriks in the Lambek tradition.[1] Here we focus on Steedman's proposal, discussing it in more detail in §8.2. The reasons for opting for Steedman's CCG account rather than Hendriks' proposal is that the former is worked out in more linguistic detail, and that it -surprisingly perhaps- appears more suitable for recasting in terms of categorial type logic. In §8.3 we present the abstract model of tune in DGL, and in §8.4 we show how to integrate the model with the SVO architecture developed in the previous chapter.

8.2 STEEDMAN'S SYNTAX-PHONOLOGY INTERFACE

Steedman proposes in (2000a) an integration, into CCG, of information structure and its realization through tune. With that, Steedman presents not only a comprehensive model of English tune and its relation to linguistic meaning. He also provides the ground for the important argument that "a theory of grammar in which phrasal intonation and information structure are reunited with formal syntax and semantics is not only possible, but much simpler than one in which they are separated."

In other words, Steedman shows that a categorial model is both possible *and preferable* over the generally adhered to GB architecture as pro-

---

[1] Recall from earlier discussions that, in fact, Moortgat & Morrill already proposed a model of prosody in (1991). Also Oehrle discusses prosody, for example in (1991) and (forthcoming). However, none of these discussions concern Pierrehumbert & Hirschberg's proposal.

posed by Selkirk. This architecture is given in Figure 8.1 (adapted from Steedman (2000a)), and shows how Selkirk proposes an autonomous structural level called "Intonation Structure" that mediates between Phonological Form (PF) and Logical Form (LF). Important to observe is that we also have the Surface Structure mediating between PF and LF, aside from the Intonation Structure. The responsibility of the Surface Structure still concerns aspects relating to the LF's Predicate-Argument structure. The additional task for Intonation Structure is to define those aspects of LF that relate to information structure.[2]

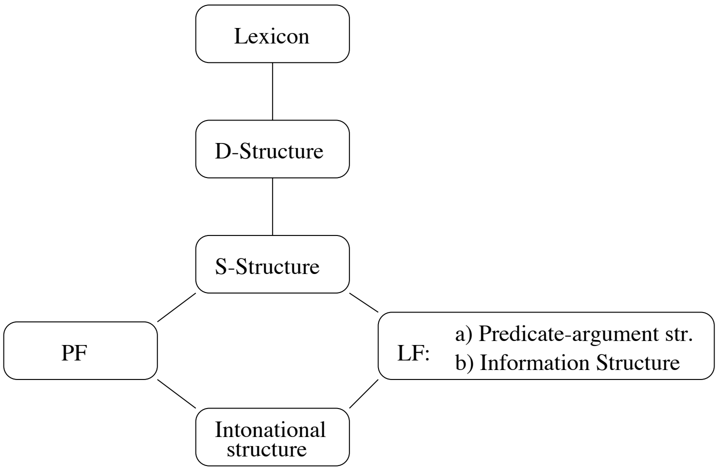

Figure 8.1: Architecture of a GB theory of Prosody

The architecture that Steedman advances is depicted in Figure 8.2. Instead of having separate levels for S-Structure and Intonational Structure we now have a single module describing surface syntax - CCG. As usual we have that operations on categories (describing surface structure) are associated with a compositional formation of a sentence's semantics, cf. (Steedman, 1996). In (Steedman, 2000a), these semantics capture both the sentence's information structure and its predicate-argument structure.[3]

---

[2] Recall that this separation of predicate-argument structure and information structure goes against the Praguian viewpoint, as we already noted in Chapter 5.

[3] The architecture in Figure 8.2 shows that a predicate-argument structure is in fact conceived of as the end-product in (Steedman, 2000a). The reason why Steedman presents the architecture this way primarily has to do with his efforts to rebuke the GB architecture. As Steedman notes himself at the end of §3.2, in practice one would not want to have a normalized term, but a more structured meaning - for example, like the representations as proposed by Materna *et al.* (1987), or as per Peregrin (1995) and elaborated in Kruijff-Korbayová (1998).

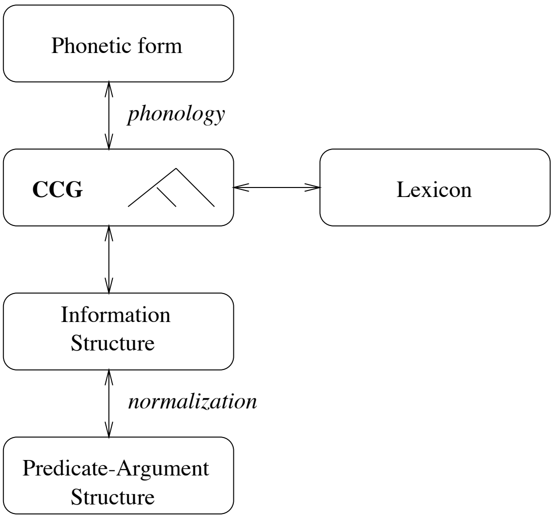

Figure 8.2: Architecture of a CCG theory of Prosody

We already discussed Steedman's theory of information structure in §5.3 (p.165ff.). Here, we briefly review how Steedman's Theme and Rheme relate to different tunes, after which we turn to Steedman's formalization in CCG.

In keeping with Pierrehumbert & Hirschberg, Steedman considers the interpretation of tune to be built from pitch accents, phrase accents, and boundary tones. We start with pitch accents. Steedman follows Beckman and Pierrehumbert in associating the following pitch accents with Theme or Rheme (in English).

(484) a. Realizing Theme: L+H*, L*+H

b. Realizing Rheme: H*, L*, H*+L, H+L*

For example, in (485), "admires" has a pitch accent L+H* (and a boundary tone LH%), whereas the focus of the Rheme has a pitch accent H*.

(485) **English**

I know that Marcel likes the man who wrotes the muscial.

But who does he ADMIRE?

$$\underbrace{\underbrace{\text{Marcel}}_{\textit{Background}}\ \underbrace{\underset{\textsf{L+H*LH\%}}{\text{ADMIRES}}}_{\textit{Focus}}}_{\textit{Theme}}\ \underbrace{\underbrace{\text{the woman who}}_{\textit{Background}}\ \underbrace{\underset{\textsf{H*}}{\text{DIRECTED}}}_{\textit{Focus}}\ \underbrace{\underset{\textsf{LL\%}}{\text{the musical}}}_{\textit{Background}}}_{\textit{Rheme}}$$

Pitch accents concern word forms, indicating the informativity of a single (simple) dependent or head. To enable the projection to larger structures, i.e. "phrase accents", Steedman assumes that pitch accents are not only related to the linguistic meaning, but that they are also expressed in the word's category. Such a category can then be composed with other categories on the condition that this composition obeys what Steedman calls "compatibility with theme- or rheme-hood".

Below we point out how this works in CCG. Before that we should still have a look at boundary tones, and where we get our tunes from in the first place. To begin with the latter, Steedman assumes what he calls a "pre-syntactic assignment". In the context of his (2000a), this naturally resolves to an assignment of tunes to words in the lexicon - but this is not a theoretical necessity.[4]

In building a compositional semantics for the boundary tones LH% and LL% and the above pitch accents, Steedman first of all considers the conceivable difference between LH% and LL%. Steedman conjectures that an H% boundary tone indicates that the Theme or Rheme it is associated to is the *hearer's* responsibility, whereas an L% boundary tone indicates that the information is the *speaker's* responsibility.[5] For example, by marking information with a boundary tone H%, we could realize various speech acts like questioning, polite requesting, ceding or holding the turn, etc.

Steedman subsequently makes a rather inelegant move, and models boundary tones as empty strings, reminiscent of transformational grammar's empty categories. A boundary tone has a functional category, with no realization, that combines with pitch accents. Important here is that the composition of a boundary tone category with a pitch accent category allows for the Theme/Rheme distinction to be projected from pitch accents onto prosodic phrases.

Thus, to recapitulate, we have an inventory of pitch accents that realize either Theme or Rheme (using Steedman's terms), and which can project over larger constructions by composition with either a boundary tone or words with unmarked intonation. Projection is handled by unification: Categories

---

[4] For example, tunes could be obtained from a speech-recognition module, and then combined with the 'bare' category information from the lexicon to form the category assignment used in the derivation. This does present a difference to for example Hendriks' (1999), in which a possible intonation is *derived* through a rewriting system.

[5] Thereby, responsibility is understood in the sense of 'ownership'.

carry features θ (Theme), ρ (Rheme) or η (unmarked), which get unified in the usual way as explained in (Steedman, 1996). The idea of unification that Steedman uses is of course very much akin to the distribution and percolation structural rules we employ in DGL (and categorial type logic in general) to handle feature information. In the next section, we sketch how we can not only remodel Steedman's proposal in terms of DGL, but actually -by using boxes and diamonds- get rid of the empty strings that Steedman uses to model boundary tones.

8.3 TUNE IN DGL

Here we provide a model of tune in DGL that we envision as an *abstract* model of tune. That is, we assume the presence of tunes that either realize contextually bound information (Steedman's θ-tunes) or contextually nonbound information (the ρ-tunes), and boundary tones, but we leave open how a specific language *instantiates* these with its own inventory of tunes.[6] Particularly, we assume the following unary modal operators for the basic intonation: ft for tunes realizing contextually nonbound elements, and ut for unmarked intonation. We can include these lexically, or let structural rules determine proper instantiations of a generally assigned int feature. Here, we keep it simple and assume a lexical assignment. At the same time, boundary tones bt are *not* modeled lexically. Instead, we model *the presence* of a boundary tone using a structural rule that rewrites a ut or ft feature into for example either $ut + bt$ or $ft + bt$. This immediately leads to a more elegant proposal, because we model boundary tones directly on elements in the prosodic structure. We no longer have to assume empty strings that model boundary tones. A basic tune system that implements these ideas for SVO is then defined as follows. Alike the models we constructed for word order as a structural indication of informativity, we assume marking with *systemic ordering*. Because we only deal with the interaction between (non-systemic) word order and tune in the next section, the definition below concerns systemic word order only.

Definition 43 (Basic SVO tune). *We define here an abstract, basic model*

---

[6] More specifically, we assume that we can monotonically extend the package we describe here with a language-specific package that (a) instantiates the tunes, and (b) regulates their possible co-occurrences and mutual orderings - in a way similar to for example VFinal's XDep and NDep packages.

of tune that is based on Steedman's CCG-based proposal in (2000a).

$$
\begin{array}{rcll}
\langle A \circ_{so>} \langle\langle B\rangle^{ft}\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle A \circ_{so>} \langle\langle B\rangle^{tun}\rangle^{inf}\rangle^{mtx} & [Tune.CFPNuclStress] \\
\langle(\langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*}) \circ_{so>} \langle\langle C\rangle^{bt+ut}\rangle^{cb}\rangle^{mtx} & \rightarrow & \langle(\langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{tun}\rangle^{inf}\rangle^{mtx} & [Tune.NCFPNuclStress] \\
\langle(\langle\langle A\rangle^{ft}\rangle^{nb*} \circ_{<so} \langle\langle B\rangle^{bt+ut}\rangle^{cb}) \circ_{so>} \langle\langle C\rangle^{ut}\rangle^{cb}\rangle^{mtx} & \rightarrow & \langle(\langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{tun}\rangle^{inf}\rangle^{mtx} & [Tune.NCFPNuclStress] \\
(A \circ_{<so} \langle\langle B\rangle^{ut+bt}\rangle^{cb}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & \rightarrow & (A \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & [Tune.SOBoundary] \\
(A \circ_{<so} \langle\langle B\rangle^{ut+bt}\rangle^{cb}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & \rightarrow & (A \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & [Tune.SOBoundary] \\
\langle\langle A\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb} & \rightarrow & \langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb} & [Tune.SOBoundary] \\
\langle\langle A\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*} & \rightarrow & \langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*} & [Tune.SOBoundary] \\
(A \circ_{so>} \langle\langle B\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & \rightarrow & (A \circ_{so>} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & [Tune.FProj] \\
(\langle\langle A\rangle^{ut}\rangle^{nb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle C\rangle^{ut}\rangle^{nb} & \rightarrow & (\langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{ut}\rangle^{nb} & [Tune.FProj] \\
(A \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & \rightarrow & (A \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle C\rangle^{ft}\rangle^{nb*} & [Tune.FProj] \\
\langle\langle A\rangle^{ut}\rangle^{nb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb} & \rightarrow & \langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb} & [Tune.FProj] \\
\langle\langle A\rangle^{ut}\rangle^{nb} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*} & \rightarrow & \langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*} & [Tune.FProj]
\end{array}
$$

$$
\begin{array}{rcll}
\langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ut+bt}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{ut+bt}\rangle^{cb} & [Tune.TProj] \\
\langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<ns} \langle\langle B\rangle^{ut+bt}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<ns} \langle\langle B\rangle^{ut+bt}\rangle^{cb} & [Tune.TProj] \\
\langle\langle\langle A\rangle^{nb} \circ_{<so} B\rangle^{ut}\rangle^{nb} & \rightarrow & \langle A\rangle^{nb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb} & [Tune.p(nb/ut, < so)] \\
\langle\langle\langle A\rangle^{cb} \circ_{<so} B\rangle^{ut}\rangle^{nb} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{nb} & [Tune.p(nb/ut, < so)] \\
\langle\langle\langle A\rangle^{cb} \circ_{<so} B\rangle^{ut}\rangle^{cb} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{cb} & [Tune.p(cb/ut, < so)] \\
\langle\langle\langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<so} B\rangle^{ut+bt}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ut+bt}\rangle^{cb} & [Tune.p(cb/ut + bt, < so)] \\
\langle\langle A \circ_{so>} B\rangle^{ut+bt}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{ut+bt}\rangle^{cb} \circ_{so>} B & [Tune.p(cb/ut + bt, so >)] \\
\langle\langle\langle A\rangle^{nb} \circ_{<so} B\rangle^{ft}\rangle^{nb*} & \rightarrow & \langle A\rangle^{nb} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*} & [Tune.p(nb*/ft, < so)] \\
\langle\langle A \circ_{so>} B\rangle^{ft}\rangle^{nb*} & \rightarrow & \langle\langle A\rangle^{ft}\rangle^{nb*} \circ_{so>} B & [Tune.p(nb*/ft, so >)] \\
\langle\langle\langle A\rangle^{cb} \circ_{<so} B\rangle^{ft}\rangle^{nb*} & \rightarrow & \langle A\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ft}\rangle^{nb*} & [Tune.p(nb*/ft, < so)] \\
\langle\langle A \circ_{so>} B\rangle^{bt+ut}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{bt+ut}\rangle^{cb} \circ_{so>} B & [Tune.p(cb/bt + ut, so >)] \\
\langle\langle\langle A\rangle^{nb*} \circ_{<so} B\rangle^{bt+ut}\rangle^{cb} & \rightarrow & \langle A\rangle^{nb*} \circ_{<so} \langle\langle B\rangle^{bt+ut}\rangle^{cb} & [Tune.p(cb/bt + ut, < so)]
\end{array}
$$

⊛

Remark 38 (Explanation of the SVO.Tune package). With the SVO.Tune package as above we provide an illustration, rather than a fully developed package. It illustrates how (an important part of) Steedman's model of tune can be formulated in DGL, at points in a more elegant way (i.e. without having to resort to empty elements).

The rules are divided into linkage (or "specification") rules and percolation rules. The linkage rules assign nuclear stress (either in canonical or non-canonical position), project the focus or the topic, and assign boundaries. The percolation rules just percolate the verbal head's features over the entire structure. Note that all these rules are defined over the headed *so* modes - non-systemic ordering is addressed in the next section. The definition thus provides a basic formalization of the use of tune to realize the information structure's focus proper in a canonical or noncanonical focus position, without resorting to any word order-related means.

The example in (486) illustrates the realization of a so-called "out-of-the-blue" sentence, using tune as the structural indication of informativity. Reading top-down, we first realize the focus proper in the canonical focus position, and then project the focus all the way leftwards.

(486)

$$\begin{array}{cl}
\vdots & \\ \hline
\langle\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<sc} (\langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & \\ \hline
\langle\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} (\langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.CFPNuclStress] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.FProj] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.FProj] \\ \hline
\langle\langle\langle\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \mathrm{tverbti}\rangle^{ut}\rangle^{nb} \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.p(nb/ut, < so)] \\ \hline
\langle\langle\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut}\rangle^{nb}\rangle^{mtx} \vdash s & [Tune.p(nb/ut, so >)] \\ \hline
\langle\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut}\rangle^{nb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut} \vdash \Box^{\downarrow}{}_{nb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{ut}\Box^{\downarrow}{}_{nb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

Next, we present two proofs with the nuclear stress in canonical focus position, but realizing a different information structure by placing boundaries. These proofs illustrate the basic idea behind formalizing boundary tones in a more elegant way. In (487) the verb is realized with a boundary tone, and in (488) the verbal head is still part of the focus so the **Actor** is realized with a boundary tone.

(487)

$$\begin{array}{cl}
\vdots & \\ \hline
\langle\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<sc} (\langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & \\ \hline
\langle\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} (\langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.CFPNuclStress] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{ut+bt}\rangle^{cb}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.SOBoundary] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{cb} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{ut+bt}\rangle^{cb}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.TProj] \\ \hline
\langle\langle\langle\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{cb} \circ_{<so} \mathrm{tverbti}\rangle^{ut+bt}\rangle^{cb} \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.p(cb/ut + bt, < so)] \\ \hline
\langle\langle\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.p(cb/ut + bt, so >)] \\ \hline
\langle\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt} \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\langle\langle\mathrm{actor}\rangle^{ut}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{ut+bt}\Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

(488)

$$\begin{array}{cl}
\vdots & \\ \hline
\langle\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<sc} (\langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & \\ \hline
\langle\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} (\langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{dc>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.CFPNuclStress] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.FProj] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \langle\langle\mathrm{tverbti}\rangle^{ut}\rangle^{nb}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.SOBoundary] \\ \hline
\langle\langle\langle\langle\langle\mathrm{actor}\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \mathrm{tverbti}\rangle^{ut}\rangle^{nb} \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.p(nb/ut, < so)] \\ \hline
\langle\langle\langle(\langle\langle\mathrm{actor}\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut}\rangle^{nb}\rangle^{mtx} \vdash s & [Tune.p(nb/ut, so >)] \\ \hline
\langle\langle(\langle\langle\mathrm{actor}\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut}\rangle^{nb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
\langle(\langle\langle\mathrm{actor}\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*}\rangle^{ut} \vdash \Box^{\downarrow}{}_{nb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
(\langle\langle\mathrm{actor}\rangle^{ut+bt}\rangle^{cb} \circ_{<so} \mathrm{tverbti}) \circ_{so>} \langle\langle\mathrm{patient}\rangle^{ft}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{ut}\Box^{\downarrow}{}_{nb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

Finally, we can realize a focus proper that is in canonical word order position but which is not sentence-final. In this case, the nuclear stress occurs in a non-canonical focus position. The proofs below illustrate two simple cases where either the **Actor** (489) or the verbal head (490) is the focus proper in the underlying information structure. Not resorting to word order, we can realize them here just using nuclear stress, like is done for example in English.

$$
(489)\qquad
\begin{array}{ll}
\vdots & \\
\hline
\langle\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<sc} (\langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}))^{mtx} \vdash s & \\
\hline
\langle\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} (\langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}))^{mtx} \vdash s & [Inf.SysOrd] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{dc>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{ft}\rangle^{nb*} \circ_{<so} \langle\langle\text{tverbti}\rangle^{bt+ut}\rangle^{cb}) \circ_{so>} \langle\langle\text{patient}\rangle^{ut}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.NCFPNuclStress] \\
\hline
\langle\langle\langle\langle\langle\text{actor}\rangle^{ft}\rangle^{nb*} \circ_{<so} \text{tverbti}\rangle^{bt+ut}\rangle^{cb} \circ_{so>} \langle\langle\text{patient}\rangle^{ut}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.p(cb/bt+ut,<so)] \\
\hline
\langle\langle\langle(\langle\langle\text{actor}\rangle^{ft}\rangle^{nb*} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{ut}\rangle^{cb}\rangle^{bt+ut}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.p(cb/bt+ut,so>)] \\
\hline
\langle\langle(\langle\langle\text{actor}\rangle^{ft}\rangle^{nb*} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{ut}\rangle^{cb}\rangle^{bt+ut}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{ft}\rangle^{nb*} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{ut}\rangle^{cb}\rangle^{bt+ut} \vdash \Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\
\hline
(\langle\langle\text{actor}\rangle^{ft}\rangle^{nb*} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{ut}\rangle^{cb} \vdash \Box^{\downarrow}{}_{bt+ut}\Box^{\downarrow}{}_{cb}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

$$
(490)\qquad
\begin{array}{ll}
\vdots & \\
\hline
\langle\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<sc} (\langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}))^{mtx} \vdash s & \\
\hline
\langle\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} (\langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf} \circ_{dc>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}))^{mtx} \vdash s & [Inf.SysOrd] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{dc>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\text{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{so>} \langle\langle\text{patient}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.SysOrd] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle\text{tverbti}\rangle^{ft}\rangle^{nb*}) \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.NCFPNuclStress] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \langle\langle\text{tverbti}\rangle^{ft}\rangle^{nb*}) \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.FProj] \\
\hline
\langle\langle\langle\langle\langle\text{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \text{tverbti}\rangle^{ft}\rangle^{nb*} \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.p(nb*/ft,<so)] \\
\hline
\langle\langle\langle(\langle\langle\text{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.p(nb*/ft,so>)] \\
\hline
\langle\langle(\langle\langle\text{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb}\rangle^{ft}\rangle^{nb*} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\
\hline
\langle(\langle\langle\text{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb}\rangle^{ft} \vdash \Box^{\downarrow}{}_{nb*}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\
\hline
(\langle\langle\text{actor}\rangle^{ut}\rangle^{nb} \circ_{<so} \text{tverbti}) \circ_{so>} \langle\langle\text{patient}\rangle^{bt+ut}\rangle^{cb} \vdash \Box^{\downarrow}{}_{ft}\Box^{\downarrow}{}_{nb*}\Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}
$$

8.4 INTERACTING TUNE AND WORD ORDER

The informativity hypotheses in Chapter 6 predict interaction between tune and word order as structural indications of informativity. In Chapter 7 we provided the architectures for word order as a structural indications of informativity, and in the current chapter we discussed tune. What both accounts have in common is that they have been defined, not relatively to the modes indicating grammatical relations like subject or object, but relatively to systemic ordering. In other words, we extend the Praguian view relating word order as a structural indication of informativity and systemic ordering to cover tune as well. There is a definite advantage in doing so. We can now describe the interaction between tune and word order in these terms as well. All we need to do is elaborate the model presented in Definition 43 such that tune is sensitive to both systemic and non-systemic ordering. To round off this chapter, we just illustrate the principal ideas on a small set of rules, (491).

(491)
$$\begin{array}{rcll}
\langle (A \circ_{ns>} B) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle (A \circ_{dc>} B) \circ_{ic>} C\rangle^{mtx} & [Inf.NonSysOrd] \\
\langle A \circ_{<ns} B\rangle^{mtx} & \rightarrow & \langle A \circ_{<dc} B\rangle^{mtx} & [Inf.NonSysOrd] \\
\langle (A \circ_{<ns} B) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle A \circ_{<ns} (B \circ_{sc>} C)\rangle^{mtx} & [Inf.NonSysOrd] \\
\langle (A \circ_{<so} B) \circ_{ns>} C\rangle^{mtx} & \rightarrow & \langle A \circ_{<so} (B \circ_{ns>} C)\rangle^{mtx} & [Inf.NonSysOrd] \\
(A \circ_{<so} B) \circ_{ns>} C & \rightarrow & A \circ_{<so} (B \circ_{ns>} C) & [Inf.NonSysOrd] \\
\langle\langle A \circ_{so>} B\rangle^{ut}\rangle^{nb} & \rightarrow & \langle\langle A\rangle^{ut}\rangle^{nb} \circ_{so>} B & [Tune.p(nb/ut, so >)] \\
\langle\langle A \circ_{ns>} B\rangle^{ut}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{ut}\rangle^{cb} \circ_{ns>} B & [Tune.p(cb/ut, ns >)] \\
\langle\langle A \circ_{ns>} B\rangle^{ut+bt}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{ut+bt}\rangle^{cb} \circ_{ns>} B & [Tune.p(cb/ut + bt, ns >)] \\
\langle\langle\langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<ns} B\rangle^{ut+bt}\rangle^{cb} & \rightarrow & \langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<ns} \langle\langle B\rangle^{ut+bt}\rangle^{cb} & [Tune.p(cb/ut + bt, < ns)] \\
\langle (A \circ_{ns>} \langle\langle B\rangle^{ut+bt}\rangle^{cb}) \circ_{ns>} \langle\langle C\rangle^{ft}\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle (A \circ_{ns>} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{ns>} \langle\langle C\rangle^{ft}\rangle^{nb*}\rangle^{mtx} & [Tune.NSOBoundary] \\
\langle (A \circ_{<ns} \langle\langle B\rangle^{ut+bt}\rangle^{cb}) \circ_{ns>} \langle\langle C\rangle^{ft}\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle (A \circ_{<ns} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{ns>} \langle\langle C\rangle^{ft}\rangle^{nb*}\rangle^{mtx} & [Tune.NSOBoundary] \\
(\langle\langle A\rangle^{ut}\rangle^{cb} \circ_{<so} \langle\langle B\rangle^{ut}\rangle^{cb}) \circ_{ns>} \langle\langle C\rangle^{ut+bt}\rangle^{cb} & \rightarrow & (\langle\langle A\rangle^{tun}\rangle^{inf} \circ_{<so} \langle\langle B\rangle^{tun}\rangle^{inf}) \circ_{ns>} \langle\langle C\rangle^{ut+bt}\rangle^{cb} & [Tune.TProj] \\
\langle A \circ_{ns>} \langle\langle B\rangle^{ft}\rangle^{nb*}\rangle^{mtx} & \rightarrow & \langle A \circ_{ns>} \langle\langle B\rangle^{tun}\rangle^{inf}\rangle^{mtx} & [Tune.CFPNuclStress]
\end{array}$$

For completeness, (491) repeats some of the rules defined in InfSVO for describing the effect of mixed word order on systemic ordering. We use these rules in the example below, (492). Besides these rules, we describe the placement of nuclear stress and of boundaries, topic projection over non-systemic ordering, and the necessary percolation rules.

(492)
$$\begin{array}{cl}
\vdots & \\ \hline
\langle\langle\langle \text{patient}\rangle^{tun}\rangle^{inf} \circ_{<dc} (\langle\langle \text{tverbti}\rangle^{tun}\rangle^{inf} \circ_{sc>} \langle\langle \text{actor}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & \\ \hline
\langle\langle\langle \text{patient}\rangle^{tun}\rangle^{inf} \circ_{<ns} (\langle\langle \text{tverbti}\rangle^{tun}\rangle^{inf} \circ_{sc>} \langle\langle \text{actor}\rangle^{tun}\rangle^{inf})\rangle^{mtx} \vdash s & [Inf.NonSysOrd] \\ \hline
\langle(\langle\langle \text{patient}\rangle^{tun}\rangle^{inf} \circ_{<ns} \langle\langle \text{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{ns>} \langle\langle \text{actor}\rangle^{tun}\rangle^{inf}\rangle^{mtx} \vdash s & [Inf.NonSysOrd] \\ \hline
\langle(\langle\langle \text{patient}\rangle^{tun}\rangle^{inf} \circ_{<ns} \langle\langle \text{tverbti}\rangle^{tun}\rangle^{inf}) \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.CFPNuclStress] \\ \hline
\langle(\langle\langle \text{patient}\rangle^{tun}\rangle^{inf} \circ_{<ns} \langle\langle \text{tverbti}\rangle^{ut+bt}\rangle^{cb}) \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.NSOBoundary] \\ \hline
\langle(\langle\langle \text{patient}\rangle^{ut}\rangle^{cb} \circ_{<ns} \langle\langle \text{tverbti}\rangle^{ut+bt}\rangle^{cb}) \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.TProj] \\ \hline
\langle\langle\langle\langle\langle \text{patient}\rangle^{ut}\rangle^{cb} \circ_{<ns} \text{tverbti}\rangle^{ut+bt}\rangle^{cb} \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{mtx} \vdash s & [Tune.p(cb/ut + bt, < ns)] \\ \hline
\langle\langle\langle(\langle\langle \text{patient}\rangle^{ut}\rangle^{cb} \circ_{<ns} \text{tverbti}) \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt}\rangle^{cb}\rangle^{mtx} \vdash s & [Tune.p(cb/ut + bt, ns >)] \\ \hline
\langle\langle(\langle\langle \text{patient}\rangle^{ut}\rangle^{cb} \circ_{<ns} \text{tverbti}) \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt}\rangle^{cb} \vdash \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I] \\ \hline
\langle(\langle\langle \text{patient}\rangle^{ut}\rangle^{cb} \circ_{<ns} \text{tverbti}) \circ_{ns>} \langle\langle \text{actor}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt} \vdash \Box^{\downarrow}{}_{cb} \Box^{\downarrow}{}_{mtx} s & [\Box^{\downarrow} I]
\end{array}$$

SUMMARY

In this chapter, we first discussed Steedman's theory integrating tune into a CCG of English. We criticized Steedman's use of empty strings to model boundary tones, and presented an abstract model of Steedman's account of tune that shows how we can model boundary tones as complex feature labels. A further distinction is that the model interprets tunes on wordgroups relative to whether these words appear in systemic ordering. This perspective takes the Praguian view on the relation between word order and systemic ordering to tune. The advantage of doing so is that the interaction between tune and word order can be (formally) described in terms of how tunes should be interpreted relative to systemically and non-systemically ordered wordgroups. We ended the chapter with a brief discussion of such a description, and showed an example involving the interaction between tune and mixed non-systemically ordered realizations of dependents in an SVO language type.

CHAPTER 9

DGL, TOPIC/FOCUS, AND DISCOURSE

A hybrid logic modeling TF-DRT

This chapter explains how we formalize the interpretation of a sentence's linguistic meaning, with its information structure, in the context of a larger discourse. We argue why not only information structure but also dependency relations are fundamentally important to discourse interpretation. To illustrate the argument, we propose a rudimentary information structure-sensitive discourse theory like (Kruijff-Korbayová, 1998) that hooks up with DGL, and in which we formalize the binding of various types of anaphors. The overall effort enables us to –in principle– cover the entire track from sentential form to linguistic meaning to discourse interpretation.

> *It is the abstractive power of ordinary speech*
> *which renders it more logically powerful than*
> *any algebra of logic hitherto developed.*
>
> – Charles S. Peirce, *Logic Notebook*, 1898

9.1 INTRODUCTION

Information structure is an essential aspect of a sentence's linguistic meaning. It indicates how the sentence's linguistic meaning is being presented as both dependent on the preceding discourse context, and how that meaning affects the context. In Chapter 5 we already explained how the important ingredients of information structure (contextual boundness) are represented in DGL, and how we derive a topic-focus articulation from the contextual boundness of the individual nodes in a linguistic meaning. Chapters 6 through 8 elaborated on how we can analyse structural indications of informativity as reflecting the underlying information structure. As an example, consider the proof in (493) and the representation of the corresponding linguistic meaning in (494).

(493)

1.	elijah $: \Box^{\downarrow}_{tun}\Box^{\downarrow}_{inf}\Diamond_{act}n$	Lex
2.	$\langle \mathrm{elijah}\rangle^{tun} : \Box^{\downarrow}_{inf}\Diamond_{act}n$	$\Box^{\downarrow}E$ (1)
3.	$\langle\langle \mathrm{elijah}\rangle^{tun}\rangle^{inf} : \Diamond_{act}n$	$\Box^{\downarrow}E$ (2)
4.	kathy $: \Box^{\downarrow}_{tun}\Box^{\downarrow}_{inf}\Diamond_{addr}n$	Lex
5.	$\langle \mathrm{kathy}\rangle^{tun} : \Box^{\downarrow}_{inf}\Diamond_{addr}n$	$\Box^{\downarrow}E$ (4)
6.	$\langle\langle \mathrm{kathy}\rangle^{tun}\rangle^{inf} : \Diamond_{addr}n$	$\Box^{\downarrow}E$ (5)
7.	letters $: \Box^{\downarrow}_{tun}\Box^{\downarrow}_{inf}\Diamond_{pat}n$	Lex
8.	$\langle \mathrm{letters}\rangle^{tun} : \Box^{\downarrow}_{inf}\Diamond_{pat}n$	$\Box^{\downarrow}E$ (7)
9.	$\langle\langle \mathrm{letters}\rangle^{tun}\rangle^{inf} : \Diamond_{pat}n$	$\Box^{\downarrow}E$ (8)
10.	$\mathrm{r}_0 : n$	Hyp
11.	$\langle \mathrm{r}_0\rangle^{act} : \Diamond_{act}n$	$\Diamond I$ (10)
12.	sent $: \Box^{\downarrow}_{tun}\Box^{\downarrow}_{inf}\Box^{\downarrow}_{vhead}(((\Diamond_{act}n\backslash_{<sc}s)/_{dc>}\Diamond_{pat}n)/_{ic>}\Diamond_{addr}n)$	Lex
13.	$\langle \mathrm{sent}\rangle^{tun} : \Box^{\downarrow}_{inf}\Box^{\downarrow}_{vhead}(((\Diamond_{act}n\backslash_{<sc}s)/_{dc>}\Diamond_{pat}n)/_{ic>}\Diamond_{addr}n)$	$\Box^{\downarrow}E$ (12)
14.	$\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} : \Box^{\downarrow}_{vhead}(((\Diamond_{act}n\backslash_{<sc}s)/_{dc>}\Diamond_{pat}n)/_{ic>}\Diamond_{addr}n)$	$\Box^{\downarrow}E$ (13)
15.	$\langle\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf}\rangle^{vhead} : ((\Diamond_{act}n\backslash_{<sc}s)/_{dc>}\Diamond_{pat}n)/_{ic>}\Diamond_{addr}n$	$\Box^{\downarrow}E$ (14)
16.	$\mathrm{q}_1 : n$	Hyp
17.	$\langle \mathrm{q}_1\rangle^{addr} : \Diamond_{addr}n$	$\Diamond I$ (16)
18.	$\langle\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf}\rangle^{vhead} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr} : (\Diamond_{act}n\backslash_{<sc}s)/_{dc>}\Diamond_{pat}n$	$/E$ (15, 17)
19.	$\mathrm{s}_1 : n$	Hyp
20.	$\langle \mathrm{s}_1\rangle^{pat} : \Diamond_{pat}n$	$\Diamond I$ (19)
21.	$(\langle\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf}\rangle^{vhead} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle \mathrm{s}_1\rangle^{pat} : \Diamond_{act}n\backslash_{<sc}s$	$/E$ (18, 20)
22.	$\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf}\rangle^{vhead} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle \mathrm{s}_1\rangle^{pat}) : s$	$\backslash E$ (11, 21)
23.	$\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}(\langle\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}\rangle^{vhead} \circ_{dc>} \langle \mathrm{s}_1\rangle^{pat}) : s$	$p(vhead, ic>)$ (22)
24.	$\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}\langle((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle \mathrm{s}_1\rangle^{pat}\rangle^{vhead} : s$	$p(vhead, dc>)$ (23)
25.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle \mathrm{s}_1\rangle^{pat})\rangle^{vhead} : s$	$p(vhead, <sc)$ (24)
26.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle \mathrm{s}_1\rangle^{pat})\rangle^{mtx} : s$	$Matrix\ is\ basic\ SVO$ (25)
27.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{tun}\rangle^{inf})\rangle^{mtx} : s$	$\Diamond E$ (9, 19, 26)
28.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle \mathrm{q}_1\rangle^{addr}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{mtx} : s$	$l(inf/tun, cb/ut)$ (27)
29.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{tun}\rangle^{inf}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{mtx} : s$	$\Diamond E$ (6, 16, 28)
30.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{tun}\rangle^{inf} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{mtx} : s$	$l(inf/tun, nb*/ft)$ (29)
31.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}((\langle\langle \mathrm{sent}\rangle^{ut+bt}\rangle^{cb} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{mtx} : s$	$l(inf/tun, cb/ut+bt)$ (30)
32.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}(\langle\langle \mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}\rangle^{ut+bt}\rangle^{cb} \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{mtx} : s$	$p(cb/ut+bt, ic>)$ (31)
33.	$\langle\langle \mathrm{r}_0\rangle^{act} \circ_{<sc}\langle\langle(\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb}\rangle^{ut+bt}\rangle^{cb}\rangle^{mtx} : s$	$p(cb/ut+bt, dc>)$ (32)
34.	$\langle\langle\langle \mathrm{elijah}\rangle^{tun}\rangle^{inf} \circ_{<sc}\langle\langle(\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb}\rangle^{ut+bt}\rangle^{cb}\rangle^{mtx} : s$	$\Diamond E$ (3, 10, 33)
35.	$\langle\langle\langle \mathrm{elijah}\rangle^{ut}\rangle^{cb} \circ_{<sc}\langle\langle(\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb}\rangle^{ut+bt}\rangle^{cb}\rangle^{mtx} : s$	$l(inf/tun, cb/ut)$ (34)
36.	$\langle\langle\langle\langle\langle \mathrm{elijah}\rangle^{ut}\rangle^{cb} \circ_{<sc}((\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{ut+bt}\rangle^{cb}\rangle^{mtx} : s$	$p(cb/ut+bt, <sc)$ (35)
37.	$\langle\langle\langle\langle \mathrm{elijah}\rangle^{ut}\rangle^{cb} \circ_{<sc}((\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{ut+bt}\rangle^{cb} : \Box^{\downarrow}_{mtx}s$	$\Box^{\downarrow}I$ (36)
38.	$\langle\langle\langle \mathrm{elijah}\rangle^{ut}\rangle^{cb} \circ_{<sc}((\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb})\rangle^{ut+bt} : \Box^{\downarrow}_{cb}\Box^{\downarrow}_{mtx}s$	$\Box^{\downarrow}I$ (37)
39.	$\langle\langle \mathrm{elijah}\rangle^{ut}\rangle^{cb} \circ_{<sc}((\mathrm{sent} \circ_{ic>} \langle\langle \mathrm{kathy}\rangle^{ft}\rangle^{nb*}) \circ_{dc>} \langle\langle \mathrm{letters}\rangle^{ut}\rangle^{cb}) : \Box^{\downarrow}_{ut+bt}\Box^{\downarrow}_{cb}\Box^{\downarrow}_{mtx}s$	$\Box^{\downarrow}I$ (38)

⊛

(494) Linguistic meaning of (493):

$$@_i([\textsc{cb}](\mathcal{E} \wedge \mathbf{send}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{elijah}) \wedge [\textsc{nb}^*]\langle\textsc{Patient}\rangle(k \wedge \mathbf{kathy}) \wedge [\textsc{nb}]\langle\textsc{Addressee}\rangle(l \wedge \mathbf{letter}))$$

with topic-focus articulation:

$$@_i([\textsc{cb}](\mathcal{E} \wedge \mathbf{send}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{elijah}) \bowtie [\textsc{nb}]\langle\textsc{Addressee}\rangle(l \wedge \mathbf{letter}) \wedge [\textsc{nb}^*]\langle\textsc{Patient}\rangle(k \wedge \mathbf{kathy}))$$

We need to make one further step. We already indicated in Chapter 5 that a representation of the form $@_i(\mathcal{T} \bowtie \mathcal{F})$ is interpreted *dynamically*. In the next section we define this process of information structure-sensitive dynamic interpretation, and in §9.3 we present a basic approach to binding.

9.2 DYNAMIC INTERPRETATION OF INFORMATION STRUCTURE

The proper place for describing the interpretation of information structure is discourse, and with that in mind we proceed in the current section as follows.

First, we consider an information structure-sensitive discourse representation theory. The principal ideas behind our proposal come from Kruijff-Korbayová (1998). We note a few problems for the typed approach taken in (Kruijff-Korbayová, 1998), and we discuss how they are overcome (already in DGL). Thereafter, we define the model-theoretic dynamic interpretation of information structure, given information structure-sensitive discourse representations. This theme is continued in the next section (9.3). With that, we have essentially arrived at a proposal that in principle covers the entire track between a sentence's surface form and its eventual interpretation-in-context, all from a Praguian view, (without the claim of course that the proposal is any way *complete*).

Kruijff-Korbayová (1998) proposes to *split* DRT's discourse representation structure (DRS) into two parts - a topic-part and a focus-part.[1] Technically, the focus-box and the topic-box are defined as λ-DRSs (Kuschert, 1996). The boxes typed non-rigidly, in that it depends on the structure of the topic and the focus which elements act as arguments and which as functors.[2] Abstractly, Kruijff-Korbayová's TF-DRS take the form as in (495).

(495) $\boxed{\text{TOPIC}} \bowtie \boxed{\text{FOCUS}}$

An example TF-DRS is given in (496), (Kruijff-Korbayová, 1998)(p.72-73). We repeat Kruijff-Korbayová's notation of dependency relations.

(496) a. **Czech**

Muž potkal v parku DÍVKU.
man-nom meet-Past in park girl-acc

"The man met a girl in a park."

$[_T(\textbf{Actor}\text{:man})_{cb}][_F(\text{meet})_{nb}(\textbf{Locative}\text{:park})_{nb}(\textbf{Patient}\text{:girl})_{nb}]$

---

[1] As Peregrin notes, there is an earlier attempt to account for topic-focus articulation in a framework at least similar to DRT. This account is Peregrin & Sgall (1986). Quoting Peregrin, "[i]n this framework, each sentence is associated with a situation-like structure (the "content" of a sentence); the "meaning" of a sentence is then understood as the class of all the embeddings of the "content" into the model. A sentence articulated into a topic and a focus is considered as true if every embedding of the "content" of its topic is meaningfully extensible to an embedding of the "content" of the whole sentence." (Peregrin, 1995)(p.237). Kruijff-Korbayová stays with DRT (that is, λ-DRT), developing an intensional logic around Peregrin's (1995) extensional account of topic-focus articulation, and is the first to propose to split a DRS representation into a topic-part and a focus-part.

[2] This presents an attempt at generalizing Jackendoff's idea of viewing the focus always as an abstraction, an idea which is also followed in (Peregrin, 1995).

b. $$\lambda P. \begin{array}{|l|}\hline x \\ \hline man(x) \\ x=? \\ P(x) \\ \hline \end{array} \bowtie \lambda\Phi.\lambda u \begin{array}{|l|}\hline e,\ y,\ p \\ \hline \Phi(meet(e,\ Actor{:}u,\ Patient{:}\ y)) \\ Locative(e,p) \\ park(p) \\ \hline \end{array}$$

A TF-DRS like the one given in (496b) can be relaxed to simulate a λ-DRS. To obtain a λ-DRS, we regard $\bowtie$ as λ-DRT's application operator "@", after which we can β-reduce the duplex T/F-condition into a $\beta\eta$-normal form, (Kruijff-Korbayová, 1998)(p.84).

However, a sentence's topic-focus articulation is usually not as neatly separated as in (496), with just one element in the topic - or the complement case, with just one element in the focus. For example, consider (497), (Kruijff-Korbayová, 1998)(p.86).

(497) a. **Czech**

Muž	dívku	potkal	v	PARKU.
man-nom	girl-acc	meet-Past	in	park

"The man met a girl in a park."

$[_T(\textbf{Actor}\text{:man})_{cb}(\textbf{Patient}\text{:girl})_{cb}][_F(\text{meet})_{nb}(\textbf{Locative}\text{:park})_{nb}]$

In the approach that Kruijff-Korbayová takes, examples like (497) present a problem. The dependents we have in the topic yield separate partial λ-DRSs. Each of these partial λ-DRSs need to be combined with the verb's predicative λ-DRS. However, as Kruijff-Korbayová notes, that would mean that there would have to be multiple functional applications joining the topic-part and the focus-part. Unfortunately, the verb's λ-DRS belongs to the focus (in the case of (497)), and so the functional application does not take place in the TF-DRS construction. Consequently, we could potentially end up with multiple λ-DRS for each part of a TF-DRS. Kruijff-Korbayová notes that this is undesirable.

There are several options open to solve this problem. From the viewpoint of type logic we could think of using pairing and projection. Alternatively, Peregrin (p.c.) proposes to use multiple λ-abstraction and conversion in which multiple arguments can be absorbed in a single application and conversion step. Kruijff-Korbayová suggests a "wrapping operation"

(1998)(p.87) that inserts a dummy variable into the topic which is of the same type as the type of the predicative focus λ-DRS, and vice versa. The result of this operation is that we obtain a partial λ-DRS that contains a variable for the material belonging to the focus, and the predicative focus λ-DRS contains variables for the material belonging to the topic. The problem with Kruijff-Korbayová's proposal is that, as a result of the wrapping operation, we obtain two λ-DRSs that are no longer β-reducible: Their types can no longer be applied to one another.

In DGL's representations of linguistic meaning with topic-focus articulation, there is no such problem. I use nominals to maintain the original dependency-based relational structure. This means that -in a trivial way-we can obtain the same effect as β-reduction/application over $\bowtie$ (as in TF-DRT) because we never took anything apart in the first place. Thus, "representation" is no longer a big concern here – the relevant representations of sentential linguistic meaning we already get from the grammar in the case of DGL. I propose to employ these representations immediately as TF-DRSs. Chapter 2 already discussed the use of hybrid logic for modeling discourse representations. Recall that there I proposed to conceive of nominals as -essentially- discourse referents, and of the propositions holding at the states identified by the nominals as the discourse conditions.

The more interesting issues concern the interpretion of these representations in the context of a larger discourse. To that end, we have to establish the effect of $\bowtie$ on interpreting the context dependent part *and* the context affecting part of a sentential linguistic meaning and its information structure. Consider (498) below. I have added the more elaborate specification of the verb's causal and temporal structure, (498c).

(498) a. The cat ate a SAUSAGE.

b. $@_h([\textsc{cb}]\langle\textsc{Actor}\rangle(c \wedge \mathbf{cat}) \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{eat}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(s \wedge \mathbf{sausage}))$

c. $@_h([\textsc{cb}]\langle\textsc{Actor}\rangle(c \wedge \mathbf{cat}) \bowtie [\textsc{nb}](\mathcal{E} \wedge @_{activity}\mathbf{eat} \wedge @_{activity}ref \wedge \langle\textsc{Past}\rangle activity) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(s \wedge \mathbf{sausage}))$

Following earlier proposals like (Peregrin, 1995) or (Kruijff-Korbayová, 1998), we consider *information structure*-discourse interpretation to be defined *dynamically.* That is, we first try to update the context with the topic, and only if that succeeds, we try to the update the context with the focus.

Now, to be able to provide this definition, we have to make sure it is clear what a representation like (498c) includes.

Each representation is considered from a particular "vantage point" - h in (498c). From this point, everything is related, starting with the event nucleus. As we already saw earlier, e.g. on page 63, the internal structure of an event nucleus is like (499).

(499) $@_{activity}\ \langle \textsc{Prep} \rangle\ achievement\ \wedge\ @_{achievement}\ \langle \textsc{Cons} \rangle\ consequent$

When we unfold (498c)'s $\mathcal{E}$ into (499), it should be clear that the *activity* nominal is the same as the nominal in the event nucleus. Furthermore, from the specification of the verbal tense, we know that the activity occured in "the" past. To be more precise, from $@_h(\mathcal{E}\ \wedge\ @_{activity}\mathbf{eat}\ \wedge\ @_{activity}ref\ \wedge\ \langle \textsc{Past} \rangle activity)$ it follows that $@_h\langle \textsc{Past} \rangle activity$, i.e. *activity* refers to a point in the past of h. Furthermore, we of course have the dependents. These are related to h through their dependency relation, and their informativity (CB/NB).[3] The way we can view this intuitively is as follows. Based on the understanding of the modeling of CB/NB as $[\cdot]$ modals, h is the vantage point from which the CB and NB set the contexts in which the dependents are to be interpreted.

To recapitulate, when we interpret a sentence's linguistic meaning, we have to do so formally from the viewpoint of h. This idea forms the basis for the definition of dynamic discourse interpretation we present below.

Definition 44 (Dynamic discourse interpretation). *We define a discourse structure* D *as a structure* $\langle \mathcal{D}, \{R_{\mathsf{D}}\}, \mathsf{HB}, \mathsf{P} \rangle$. HB *is a hybrid logical back-and-forth structure with spatial extension, as defined in Definition 10 (page 86).* P *is a sorted structure on which we interpret objects and properties, which may overlap with* HB*'s sorted spatial structure.* $\mathcal{D}$ *is a set of nominals points in a discourse, and* $\{R_{\mathsf{D}}\}$ *is a set of relations modelling models in* D. $\{R_{\mathsf{D}}\}$ *includes at least* $\lhd$*, the relation that defines a total order over the nominals in* D*. A discourse model* $\mathfrak{M}_{\mathsf{D}}$ *is a tuple* (D, V) *with* D *a discourse structure and* V *a hybrid valuation. To interpret a sentence's linguistic meaning represented as* $@_h(\mathcal{T} \bowtie \mathcal{F})$, $\mathfrak{M}_{\mathsf{D}}, w \models @_h(\mathcal{T} \bowtie \mathcal{F})$ *with* w *the denotation of* h *iff* $\mathfrak{M}_{\mathsf{D}}, w \models @_h(\mathcal{T})$.

⊛

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[3] Recall that it furthermore holds that they are related to the verbal head directly through their dependency relation.

Definition 44 gives the basics for a dynamic model of interpretation, modeling $\bowtie$ in a way similar to (Kruijff-Korbayová, 1998)(p.79ff) or the dynamic conjunction discussed in (Muskens et al., 1996). The important step now is to define a notion of discourse accessibility, which first and formost relies on how we understand contextual boundness. We already provided a very basic definition of accessibility in Definition 5 on page 29. Here we refine Definition 5 in the light of Definition 44 and a more detailed specification of the model-theoretic semantics of $[\textsc{cb}]\phi$, $[\textsc{nb}]\phi$.

Definition 45 (Discourse accessibility). *We already provided a very basic definition of accessibility in Definition 5 on page 29. Here we refine Definition 5 in the light of Definition 44. For* $\mathfrak{M}_{\mathsf{D}}, w \models @_h(\mathcal{T})$ *to hold we need to specify the meaning of contextual boundness. We first of all have the following standard definitions:*

$$\begin{array}{lll}
\mathfrak{M}, w \models \phi \ \wedge \ \psi & \textit{iff} & \mathfrak{M}, w \models \phi \textit{ and } \mathfrak{M}, w \models \psi \\
\mathfrak{M}, w \models \langle \pi \rangle \phi & \textit{iff} & \exists w' (w R_\pi w' \ \& \ \mathfrak{M}, w' \models \phi) \\
\mathfrak{M}, w \models [\pi] \phi & \textit{iff} & \forall w' (w R_\pi w' \Rightarrow \mathfrak{M}, w' \models \phi)
\end{array}$$

For the modal relation CB *we define the accessibility relations* R_{cb} *as follows:* $w R_{cb} w'$ & $\mathfrak{M}, w' \models \phi$ *means that there is a state* p *in* $\mathcal{D}$, $p \lhd w$, *such that at* p *we either have that* $\mathfrak{M}, p \models [\textsc{cb}]\phi$ *or* $\mathfrak{M}, p \models [\textsc{nb}]\phi$. *The accessibility relation* R_{nb} *connects* D *with* HB, P, *over which it models universal accessibility. For* $\textsc{cb}^*$ *we require that* $@_h[cb*]a \rightarrow (@_h[cb*]a \ \wedge \ @_h[cb*]b \ \wedge \ \neg @_a b)$, *i.e. if there exists an accessible antecedent* a *then there exists another accessible antecedent* b *different from* a.

Next, for a dependency relation δ *we have that the accessibility relation* R_δ *is defined from* $\mathsf{HB} \cup \mathsf{P}$ *to* $\mathsf{HB} \cup \mathsf{P}$, *interpreting* $\langle \delta \rangle \phi$ *on a state* s *that is of the right sort given* ϕ.

Hence, if we consider the generic discourse (modal) relation $\mathfrak{R}$ *to be modeled with* $\lhd$ *as its underlying accessibility relation, then we can specify* discourse accessibility *in more detail as follows.*

$$@_p \langle XS \rangle a \rightarrow @_p \langle XS \rangle a \ \wedge \ @_i [\iota] \langle \delta \rangle p \ \wedge \ @_j \langle \mathfrak{R} \rangle i \ \wedge \ @_j [\iota'] \langle \delta' \rangle a,$$
for any $\delta, \delta' \in \Delta$, $\iota, \iota' \in \{cb, nb\}$.

⊛

Remark 39 (The nature of contextual boundness). The idea that Definitions 44 and 45 describe with so many words is rather simple: *A contextually bound item is an item that was introduced earlier in the discourse, and possibly refered to after its introduction.* Consider Figure 9.1. The discourse "progresses" from left to right, with $h \lhd h' \lhd h''$. Under h we introduce an **Actor** a, as an NB item. Subsequently, we have a linguistic meaning (under h') in which the **Actor** is CB - referring to the earlier, newly introduced a, along (1). Finally, we refer once more to the contextually bound item, under h'' - but note that Definition 45 enables us to just 'return' along (2) to the latest reference to a (which is at a' under h'). In other words, contextual boundness is a relation over items refered to, or introduced into, the discourse. By quantifying over this (transitive) relation we can formally define the Praguian notion of salience.

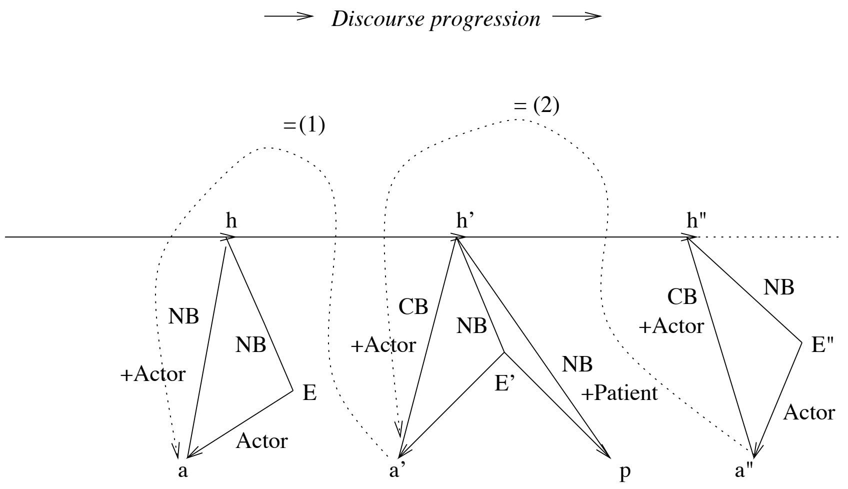

Figure 9.1: The nature of contextual boundness

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Definition 46 (Salience). *The salience of an item x at a current point in the discourse, h, is defined as follows. If x is NB under h, then the salience of x is 0:* ***Salience***$(h[\mathrm{NB}]x)=0$. *If x is CB under h, then the salience of x is defined as follows. Let $\lhd^*$ be the non-reflexive transitive closure of $\lhd$. Let $l^{nb}(h,x)$ be the length of the path from h to h', with $h' \lhd^* h$ and x NB under h'. Let $l^{cb}(h,x)$ be the length of the path from h to h'', with x last CB-refered to under h''. If there is no h", then $l^{cb}(h,x)$=0. The salience of a CB item x under h is calculated as in (500), after (Sgall et al., 1986).*

(500) $$\textbf{\textit{Salience}}(h[\text{CB}]x) = \begin{cases} l^{nb}(h,x)\text{-}l^{cb}(h,x) & \textit{if } x \textit{ is realized as a pronoun} \\ 1 & \textit{if } x \textit{ is realized as a definite noun} \end{cases}$$

⊛

Remark 40 (The use of salience). Based on Definition 46 we can establish the salience of the items in Figure 9.1 as follows. Assume that a' is realized as a definite nominal head, and a'' as a pronoun. Then, the salience of a' is 1, and the salience of a'' is $2-1=1$ as well. Note that if we would have a subsequent reference to a, a''', realized as another pronominal expression, then the salience of a''' would be 2. This constitutes a slight difference with Sgall et al's proposal, who would assign a''' a salience equal to its previous value, i.e. 1.

The role salience plays in the discourse theory we propose here is that of providing an ordering over possible antecedents, from a given point in the discourse. If for a CB item under h there are several possible antecedents to which it could be referring, then by definition we take the *most salient possible antecedent* as the antecedent for the reference.

⊛

Finally, to round off our discussion in this section, we address the issue of how sentential linguistic meaning gets actually merged with the already established discourse.

Definition 47 (Merging sentential meaning with discourse). *Given a specification of sentential linguistic meaning,* $@_h(\mathcal{T} \bowtie \mathcal{F})$ *and a discourse* $\mathfrak{D}$*, both formulated as hybrid logical formulas. By definition we have that* $\mathfrak{M}_{\mathsf{D}} \models \mathfrak{D}$*. The empty discourse is modeled as* $\top$*. The merge-operator* $\otimes$ *for merging* $\mathfrak{D}$ *and* $@_h(\mathcal{T} \bowtie \mathcal{F})$*,* $\mathfrak{D} \otimes @_h(\mathcal{T} \bowtie \mathcal{F})$ *is defined as follows.*

i. *If* $\mathfrak{D} = \top$*, then take a nominal* $d \in \mathsf{D}$*, designate* d *as* $\mathbf{current}(d)$*, and interpret* $@_d(\mathcal{T} \bowtie \mathcal{F})$ *(equating* d *and* h*,* $@_d h$*) as per Definition 44. Let* $\mathfrak{D} = @_d(\mathcal{T} \bowtie \mathcal{F})$

ii. *If* $\mathfrak{D} \neq \top$*, then take a nominal* $d \in \mathsf{D}$ *for which it holds that* $d' \lhd d$*,* $\mathbf{current}(d')$*. Evaluate* $@_d(\mathcal{T} \bowtie \mathcal{F})$ *as per Definition 44. Let* $\mathfrak{D} = \mathfrak{D} \wedge @_{d'}\langle\mathfrak{R}\rangle d \ \wedge\ @_d(\mathcal{T} \bowtie \mathcal{F})$*, and set* $\mathbf{current}(d)$*.*

⊛

Examples follow in the next section, after we have discussed (anaphoric) binding in more detail.

9.3 BINDING ACROSS (CLAUSAL) BOUNDARIES

In the previous sections we discussed in detail how information structure (topic-focus articulation) is represented in linguistic meaning, and how it guides the interpretation of linguistic meaning in a discourse context. Particularly, we described dynamic, information structure-sensitive interpretation, how that interpretation relies on contextual boundness and salience, and how a discourse context can get extended. In the current section, we put these definitions to use.

Our aim here is to look in more detail at the binding of anaphora. Intrasentential binding of anaphora already has received a fair amount of attention in the categorial grammar community and beyond. There is, as Oehrle (1999) remarks, already a well-developed account of binding phenomena, building on work by Bach and Partee, and Chierchia, and developed further by people like Szabolcsi, Morrill (1990; 1994), Hepple (1990), Dowty, Jacobson, and -most recently- Jäger (to appear). The common thread through the various accounts seems to be to treat a pronoun (or anaphor) as a type that enables the pronoun to "travel" through the structure, copy the semantics of its anchor, and then "travel" back to the point where it should reside in the structure. Oehrle points out various theoretical as well as empirical issues (pp.222-223, (Oehrle, 1999)) that could be raised against such an account.

Oehrle himself explores a different avenue, along the lines of dynamic interpretation.[4] The basic idea is to discern two types of binders in the context, namely a set of *discourse binders* $\mathcal{D}$ and a set of *local binders* $\mathcal{L}$, and carry information from an anchor (a local or a discourse binder) in the context *to* the anaphor. Oehrle achieves this as follows. Firstly, each element in the lexicon is marked with a unary modal that indicates its sensitivity to (referential) context, i.e. in what set(s) of binders its antecedent could be looked for. Secondly, different modes of composition are used to control

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[4] Oehrle presents an account of binding phenomena that combines categorial type logic with the idea of dynamic interpretation as argued for by e.g. Crouch and Van Genabith or in this dissertation. Oehrle's account dates back to 1995. It was developed independently of the account in (Crouch and van Genabith, 1998).

the dynamics (or influence) of contexts in a way that is similar to the boxes in DRT controlling accessibility. Thirdly, associated to each distinguished unary modal is a rewrite rule that specifies how it depends on $\mathcal{D}$ and $\mathcal{L}$, and how it affects them. Once a proof completes, and we have obtained a syntactic structure and its corresponding meaning representation, we can try to *rewrite* the representation we have obtained. Rewriting goes by the rewrite rules for the unary modals, and results in a representation that has an input context, filled-in semantics for antecedents (by means of "discourse referents"), and an output (or *updated*) context.

Thus, Oehrle provides an account of binding that involves an explicit notion of *context*, which in principle enables us to lift the account to the level of discourse and deal with both intrasentential *and* intersentential reference. Interestingly enough, Jäger (to appear) discusses a type-logical reformulation of Jacobson's variable-free treatment of anaphoric reference, and briefly explores such a possible extension to type-logical grammar to cover intersentential anaphora as well.

The approach I propose here employs mechanisms that we can apply to model both intrasentential and intersentential binding.[5] The basic idea behind these mechanisms was already introduced in Chapter 2 - use nominals and jump-operators to model contextual reference. For example, recall from page 30 that we can model pronominal reference abstractly as $(k \wedge @_k \langle XS \rangle (k' \wedge \bigwedge conditions))$: From the pronoun's state k we need to be able to relate to an XS accessible state k' where *conditions* hold.

The differentiation we make here is in the *context* where we can look for a nominal to jump to. Essentially, we follow up here on the idea to distinguish a local and a global context, as employed for example in Oehrle (1999). To bring about this distinction we make a difference between discourse accessibility relations that can reach over $\mathfrak{R}$ (relating different sentences, i.e. global context) and those that cannot (local context). For example, we have specified the accessibility (modal) relation XS as follows (501).

(501) *An antecedent a is accessible to an anaphor p if that antecedent is a dependent occurring under a head to which p's head is related in the established*

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[5] A disclaimer applies here: I do not provide a model of quantifiers in this dissertation, and thus any interplay between quantifier binding and anaphoric binding is left out of the discussion. For categorial grammar-based proposals for how to treat such phenomena, see for example (Morrill, 1994), (Moortgat, 1997), (Oehrle, 1999), (Jäger, to appear).

context.

$@_p\langle XS\rangle a \rightarrow @_p\langle XS\rangle a \ \wedge\ @_i[\iota]\langle\delta\rangle p \ \wedge\ @_j\langle\mathfrak{R}\rangle i \ \wedge\ @_j[\iota']\langle\delta'\rangle a$,
for any $\delta, \delta' \in \Delta$, $\iota, \iota' \in \{cb, nb\}$.

If we would specify the semantics for a reflexive personal pronoun using XS as above (18), then we would allow for it to be bound by an antecedent outside the sentence it appears in. Clearly, this is not what we want – a reflexive pronoun should be bound locally. Instead of XS we propose to use a local context accessibility relation lXS. lXS cannot reach over $\mathfrak{R}$.

(502) *A dependent j realized as a reflexive pronoun can be bound by a dependent k of type **Actor**, **Patient** or **Addressee** that modifies the same head i as j does.*
$@_j\langle lXS\rangle k \rightarrow @_j\langle lXS\rangle k \ \wedge\ @_i[\iota]\langle\delta\rangle k \ \wedge\ @_i[\iota']\langle\delta'\rangle j$,
for any $\delta \in \{\textbf{Actor}, \textbf{Patient}, \textbf{Addressee}\}$, $\delta' \in \Delta$, $\iota, \iota' \in \{cb, nb\}$.

The pure formula in (502) states that a node k is locally accessible from j if j and k are sisters under the same head, regardless of their individual contextual boundness, and k is either an **Actor**, **Patient**, or **Addressee** (cf. Petkevič (in prep)(p.98) and references therein to work by Hajičová and by Panevová). If we give a reflexive pronoun a lexical meaning of the form $(k \wedge @_k\langle \text{LXS}\rangle(k' \wedge \bigwedge \textit{conditions}))$ then we are able to handle examples like (503).

(503) **English**
Elijah SHAVES himself.

(504) i. $@_i([\text{NB}](\mathcal{E} \ \wedge\ \textbf{shave}) \ \wedge\ [\text{CB}]\langle\text{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textit{male})$
$\wedge\ [\text{CB}]\langle\text{Patient}\rangle(p \ \wedge\ @_p\langle\text{LXS}\rangle(a \ \wedge\ \textit{male})))$

ii. i. + (502) $\rightarrow @_i([\text{NB}](\mathcal{E} \wedge \textbf{shave}) \wedge [\text{CB}]\langle\text{Actor}\rangle(e \wedge \textbf{Elijah} \wedge \textit{male})$
$\wedge\ [\text{CB}]\langle\text{Patient}\rangle(p \ \wedge\ @_p\langle\text{LXS}\rangle(e \ \wedge\ \textit{male})))$

iii. $@_i([\text{NB}](\mathcal{E} \ \wedge\ \textbf{shave}) \ \wedge\ [\text{CB}]\langle\text{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textit{male})$
$\wedge\ [\text{CB}]\langle\text{Patient}\rangle(p \ \wedge\ @_p\langle\text{LXS}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textit{male})))$

However, how about examples like (505)?

(505) **English**
Elijah told Christopher that he shaves himself.

We can make various observations about (505). First of all, the antecedent of the anaphor *he* can be locally resolved as either *Elijah* or *Christopher*, or globally to any suitable antecedent. To achieve that, we have to make it possible for XS to do so – on (501) only a suitable antecedent in the global context would be found. Secondly, by binding the reflexive pronoun to the **Actor**, and the anaphor to its antecedent, the reflexive pronoun should also become bound to the anaphor's antecedent. The additional rule in (506) achieves the possibility to locally bind an anaphor. The rule covers the simple situation where the antecedent is a dependent of the same head that the embedded clause is a dependent of.

(506) *If the anaphor occurs in an embedded clause (a type δ-dependent) under a head h, then a dependent sister (of type δ') of that dependent under h can serve as antecedent.*

$$@_d\langle\mathrm{XS}\rangle a \;\rightarrow\; @_h[\iota'']\langle\delta''\rangle[\iota]\langle\delta\rangle d \;\wedge\; @_h[\iota']\langle\delta'\rangle a \;\wedge\; @_d\langle\mathrm{XS}\rangle a$$

for any $\delta, \delta', \delta'' \in \Delta$, $\iota, \iota', \iota'' \in \{cb, nb\}$.

A more complex situation is illustrated in (507).

(507) **English**
Elijah liked the sausage that he bought for himself.

The rule in (508) covers this more complex situation. where the anaphor occurs in an embedded clause (a type Δ-dependent) that modifies another dependent (of type δ'), a dependent sister of whom (type δ'') can serve as antecedent.

(508) *If the anaphor occurs in an embedded clause (a type δ'''-dependent) that modifies another dependent (of type δ'), then a dependent sister (of type δ'') of that dependent can serve as antecedent.*

$$@_d\langle\mathrm{XS}\rangle a \;\rightarrow\; @_c\langle\delta'''\rangle[\iota]\langle\delta\rangle d \;\wedge\; @_h[\iota']\langle\delta'\rangle c \;\wedge\; @_h[\iota'']\langle\delta''\rangle a \;\wedge\; @_d\langle\mathrm{XS}\rangle a$$

for any $\delta, \delta', \delta'', \delta''' \in \Delta$, $\iota, \iota', \iota'' \in \{cb, nb\}$.

Finally, as a result of the inference trying to establish antecedents for contextual references in a sentence's linguistic meaning we obtain first of all *links*. This is different from traditional approaches, where we fill in the meaning of the antecedent rather than keeping explicit the relation between reference and referent. By definition we rule that if we have that a dependent

d of type δ refers to an accessible antecedent a, then the head of d also relates via δ to a.

(509) *If a reference p has as antecedent a, and p is a dependent of type δ modifying a head h, then a can be considered to be the δ dependent of h.*
$@_p\langle\chi\rangle a \ \wedge\ @_h[\iota]\langle\delta\rangle p \ \rightarrow\ @_h[\iota]\langle\delta\rangle a$
for any $\delta, \delta' \in \Delta$, $\iota \in \{cb, nb\}$, $\chi \in \{lXS, XS\}$

Thus, for (503) we obtain the representation as in (510), based on applying (509) to (504).

(510) $@_i([\textsc{nb}](\mathcal{E} \ \wedge\ \textbf{shave}) \ \wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ male)$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ male))$

To recapitulate, we distinguish global and local contexts by differentiating the (discourse) accessibility relations that can (or cannot) range over them. When the lexical meaning of a (reflexive) pronoun states that it needs to have an accessible antecedent, then this meaning can only be interpreted if there is indeed an accessible dependent that can serve as antecedent. Depending on the kind of pronoun we are dealing with, the antecedent has to be in the same sentence (e.g. reflexive pronoun case) or may be found in preceding sentences. Finally, given the rules in (501) through (509), it is easy to verify that we obtain the usual nondeterminism for sentences like (505). Like (Oehrle, 1999) we obtain three readings, (511).

(511) $@_h([\textsc{cb}](\mathcal{E}_{\mathit{1}} \ \wedge\ \textbf{tell}) \ \wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Addressee}\rangle(c \ \wedge\ \textbf{Christopher} \ \wedge\ \textbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle([\textsc{nb}](\mathcal{E}_{\mathit{2}} \ \wedge\ \textbf{shave})$
$\wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(p \ \wedge\ @_p\langle\textsc{xs}\rangle(a \ \wedge\ \textbf{male}))$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(p' \ \wedge\ @_{p'}\langle\textsc{xs}\rangle(a' \ \wedge\ \textbf{male}))))$

a. Applying (506), (509), (502), (509):
$@_h([\textsc{cb}](\mathcal{E}_{\mathit{1}} \ \wedge\ \textbf{tell}) \ \wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Addressee}\rangle(c \ \wedge\ \textbf{Christopher} \ \wedge\ \textbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle([\textsc{nb}](\mathcal{E}_{\mathit{2}} \ \wedge\ \textbf{shave})$
$\wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textbf{male})))$

b. Applying (506), (509), (502), (509):
$@_h([\textsc{cb}](\mathcal{E}_{\mathit{1}} \ \wedge\ \textbf{tell}) \ \wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(e \ \wedge\ \textbf{Elijah} \ \wedge\ \textbf{male})$

$\wedge\ [\textsc{cb}]\langle\textsc{Addressee}\rangle(c\ \wedge\ \mathbf{Christopher}\ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle([\textsc{nb}](\mathcal{E}_2\ \wedge\ \mathbf{shave})$
$\qquad\wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(c\ \wedge\ \mathbf{Christopher}\ \wedge\ \mathbf{male})$
$\qquad\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(c\ \wedge\ \mathbf{Christopher}\ \wedge\ \mathbf{male})))$

c. For some suitable antecedent k that is accessible in the global context, applying (501), (509), (502), (509):
$@_h([\textsc{cb}](\mathcal{E}_1\ \wedge\ \mathbf{tell})\ \wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(e\ \wedge\ \mathbf{Elijah}\ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Addressee}\rangle(c\ \wedge\ \mathbf{Christopher}\ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle([\textsc{nb}](\mathcal{E}_2\ \wedge\ \mathbf{shave})$
$\qquad\wedge\ [\textsc{cb}]\langle\textsc{Actor}\rangle(k\ \wedge\ \cdot\ \wedge\ \mathbf{male})$
$\qquad\wedge\ [\textsc{cb}]\langle\textsc{Patient}\rangle(k\ \wedge\ \cdot\ \wedge\ \mathbf{male})))$

Reflecting on the rules presented in (501) through (509), we can observe that we mostly leave the dependency relations and the informativity of both the antecedent and the (reflexive) pronoun unspecified (except (502)). The criticism could now be raised that there "thus" would seem little use in contextual reference resolution for a dependency-based specification of linguistic meaning.

Rather than being an unnecessary evil, it –naturally– is a nice feature that can be conveniently used to deal with intricate phenomena. For example, consider (512) adapted from (Steedman, 1996)(p.16).

(512) **English**

a. The pictures of herself/her in *Newsweek* embarrassed Kathy.
b. The pictures of *himself/him in *Newsweek* embarrassed Kathy's mother.

Example (512a) illustrates an *exempt anaphor*. This is a type of anaphor that can usually be substituted by an ordinary pronoun, making it different from the normal bound anaphora. Mostly, exempt anaphors take as their antecedents what the literature calls "perceivers" or "experiencers". Here we understand them to refer to a **Patient**. Using a narrowed down version of rule (502) we can capture precisely this behavior, (513). If we assign an exempt anaphor a lexical meaning of the kind $(k \wedge @_k\langle xlXS\rangle(k' \wedge \bigwedge \mathit{conditions}))$, then (513) explains the uninterpretability of (512b).

(513) *A dependent j realized as an exempt anaphor can be bound by a dependent k of type **Patient** that modifies the same head i as j does.*

$@_j\langle xlXS\rangle k \rightarrow @_j\langle xlXS\rangle k \ \wedge\ @_i[\iota]\langle \mathbf{Patient}\rangle k \ \wedge\ @_i[\iota']\langle\delta'\rangle j$,
for any $\delta' \in \Delta$, $\iota, \iota' \in \{cb, nb\}$.

The examples I have presented so far deal with the resolution of (contextual) reference within the scope of a single sentence. The approach easily and uniformly extends to the resolution across sentential boundaries. To round of this chapter, I discuss a simple example that captures, in a nutshell, the mechanisms discussed in this chapter.

Example (From sentence to discourse interpretation). Consider the tiny discourse given in (514).

(514) **English**

a. Elijah went TO A STORE.

b. Elijah bought COWBOY BOOTS for himself.

c. He LIKES them.

The grammar analyses of the sentences in (514) are trivial. Therefore, we immediately turn to the linguistic meaning. First, consider (514a). We can analyze this as an all-focus sentence, which results in the linguistic meaning given in (515).

(515) a. $@_h([\textsc{nb}](\mathcal{E} \ \wedge\ \mathbf{go}) \ \wedge\ [\textsc{nb}]\langle \textsc{Actor}\rangle(e \ \wedge\ \mathbf{Elijah} \ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{nb}]\langle \textsc{Direction:WhereTo}\rangle(s \ \wedge\ \mathbf{store} \ \wedge\ \mathbf{male})$

b. linguistic meaning with topic-focus articulation:
$@_h(\top \bowtie [\textsc{nb}](\mathcal{E} \ \wedge\ \mathbf{go}) \ \wedge\ [\textsc{nb}]\langle \textsc{Actor}\rangle(e \ \wedge\ \mathbf{Elijah} \ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{nb}]\langle \textsc{Direction:WhereTo}\rangle(s \ \wedge\ \mathbf{store} \ \wedge\ \mathbf{male})$

Merging (515b) with a new discourse $\mathcal{D}$ gives us the discourse in (516).

(516) $\mathcal{D} = @_d(\top \bowtie [\textsc{nb}](\mathcal{E} \ \wedge\ \mathbf{go}) \ \wedge\ [\textsc{nb}]\langle \textsc{Actor}\rangle(e \ \wedge\ \mathbf{Elijah} \ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{nb}]\langle \textsc{Direction:WhereTo}\rangle(s \ \wedge\ \mathbf{store} \ \wedge\ \mathbf{male})$,
$\mathbf{current}(\mathrm{d})$.

Next, consider the linguistic meaning for (514b) given (517). This time, *Elijah* is CB, as is the **Beneficiary** realized as a reflexive pronoun. The verbal head and the **Patient** *cowboy boots* are NB.

(517) a. $@_h([\textsc{nb}](\mathcal{E} \ \wedge\ \mathbf{buy}) \ \wedge\ [\textsc{cb}]\langle \textsc{Actor}\rangle(e \ \wedge\ \mathbf{Elijah} \ \wedge\ \mathbf{male})$
$\wedge\ [\textsc{nb}]\langle \textsc{Patient}\rangle(b \ \wedge\ \mathbf{cowboy-boots} \ \wedge\ \mathbf{plural})$
$\wedge\ [\textsc{cb}]\langle \textsc{Beneficiary}\rangle(p \ \wedge\ @_p\langle \textsc{lXS}\rangle(a \ \wedge\ \mathbf{male})))$

b. linguistic meaning with topic-focus articulation:
$@_h([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(p \wedge @_p\langle \mathrm{LXS}\rangle(a \wedge \mathbf{male}))$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$

c. Resolved local contextual reference:
$@_h([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$

Merging (517c) with the existing discourse (516) is straightforward. There is no conflict in updating (516) with the topic $@_h([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$. The new discourse then becomes as in (518).

(518) $\mathcal{D} =$
$@_d(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{go}) \wedge [\textsc{nb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{nb}]\langle\textsc{Direction:WhereTo}\rangle(s \wedge \mathbf{store} \wedge \mathbf{male}),$
$\wedge @_d\langle\mathcal{R}\rangle d'$
$\wedge @_{d'}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$

current(d’).

Finally, consider (514c). Only the verb is NB, whereas the two anaphora are CB, (519).

(519) a. $@_h([\textsc{nb}](\mathcal{E} \wedge \mathbf{like}) \wedge [\textsc{cb}]\langle\textsc{Actor}\rangle(p \wedge @_p\langle\textsc{xs}\rangle(a \wedge \mathbf{male}))$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(p' \wedge @_{p'}\langle\textsc{xs}\rangle(a' \wedge \mathbf{plural})))$

b. linguistic meaning with topic-focus articulation:
$@_h([\textsc{cb}]\langle\textsc{Actor}\rangle(p \wedge @_p\langle\textsc{xs}\rangle(a \wedge \mathbf{male}))$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(p' \wedge @_{p'}\langle\textsc{xs}\rangle(a' \wedge \mathbf{plural})) \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{like}))$

Updating the discourse of (518) with the topic of (519b) means we have to be able to resolve the referents for the two anaphora.

(520) i. $\mathcal{D} =$
$@_d(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{go}) \wedge [\textsc{nb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{nb}]\langle\textsc{Direction:WhereTo}\rangle(s \wedge \mathbf{store} \wedge \mathbf{male}),$
$\wedge @_d\langle\mathcal{R}\rangle d'$
$\wedge @_{d'}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$
$\wedge @_{d'}\langle\mathcal{R}\rangle d''$

$@_{d''}([\textsc{cb}]\langle\textsc{Actor}\rangle(p \wedge @_{p}\langle\textsc{xs}\rangle(a \wedge \mathbf{male}))$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(p' \wedge @_{p'}\langle\textsc{xs}\rangle(a' \wedge \mathbf{plural})))$

ii. Using rules (501) and (509), resolve first the antecedent for p, and replace for the antecedent's meaning:
$\mathcal{D} =$
$@_{d}(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{go}) \wedge [\textsc{nb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{nb}]\langle\textsc{Direction:WhereTo}\rangle(s \wedge \mathbf{store} \wedge \mathbf{male}),$
$\wedge @_{d}\langle\mathcal{R}\rangle d'$
$\wedge @_{d'}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$

$\wedge @_{d'}\langle\mathcal{R}\rangle d''$
$@_{d''}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(p' \wedge @_{p'}\langle\textsc{xs}\rangle(a' \wedge \mathbf{plural})))$

iii. Next, using again rules (501) and (509), resolve first the antecedent for p', and replace for the antecedent's meaning:
$\mathcal{D} =$
$@_{d}(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{go}) \wedge [\textsc{nb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{nb}]\langle\textsc{Direction:WhereTo}\rangle(s \wedge \mathbf{store} \wedge \mathbf{male}),$
$\wedge @_{d}\langle\mathcal{R}\rangle d'$
$\wedge @_{d'}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$

$\wedge @_{d'}\langle\mathcal{R}\rangle d''$
$@_{d''}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$

Thus, we can successfully update the discourse with the topic of (519b). Subsequently, we can complete the discourse with the focus, after which we obtain (521).

(521) $\mathcal{D} =$
$@_{d}(\top \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{go}) \wedge [\textsc{nb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{nb}]\langle\textsc{Direction:WhereTo}\rangle(s \wedge \mathbf{store} \wedge \mathbf{male}),$
$\wedge @_{d}\langle\mathcal{R}\rangle d'$
$\wedge @_{d'}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male}) \wedge [\textsc{cb}]\langle\textsc{Beneficiary}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{buy}) \wedge [\textsc{nb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}))$
$\wedge @_{d'}\langle\mathcal{R}\rangle d''$
$@_{d''}([\textsc{cb}]\langle\textsc{Actor}\rangle(e \wedge \mathbf{Elijah} \wedge \mathbf{male})$
$\wedge [\textsc{cb}]\langle\textsc{Patient}\rangle(b \wedge \mathbf{cowboy} - \mathbf{boots} \wedge \mathbf{plural}) \bowtie [\textsc{nb}](\mathcal{E} \wedge \mathbf{like}))$

current(d”).

This concludes the example. ⊛

SUMMARY

In this chapter we presented a basis for an information structure-sensitive discourse representation theory *à la* (Kruijff-Korbayová, 1998). Within that proposal, we explored how we can could give an account for binding anaphora. The approach we take is different from more traditional proposals like Morrill (2000) or Jäger (to appear), where resolution of various kinds of anaphora is performed directly in the derivation. Here, alike Oehrle (1999), we consider an integration with a more *dynamic* perspective.

The proposal we advance maintains a close relation between the representations the grammar delivers, and the structures we handle in the discourse theory. We have dependency relations and information structure, both of which are fundamentally important to explain various aspects of discourse interpretation: for example, information structure for coherence, and dependency relations for resolution of exempt anaphora.

A distinct advantage of our approach is that we are able to relate grammar and discourse without having to assume an indexing mechanism that bypasses resolution, like (Van Eijck and Kamp, 1997) do. At the same time, we can provide a compositional approach to explaining the interpretation of a sentence, both grammatically (leading to linguistic meaning) and as related to discourse (leading to an updated discourse model).

SUMMARY TO PART 2

> "But it must be remembered that such theories account for what has happened, not what could have happened."
> – Abbe Mowshowitz, *The Conquest of Will*

OVERVIEW

In this second part I discussed at length how information structure is a fundamental aspect of explaining the grammatical system of language. In Chapter 5 I started with a presentation of several theories of information structure: FGD's theory of topic-focus articulation, Steedman's Theme/Rheme, and Vallduví's information packaging. All these theories share the view that an account of information structure should reflect both "syntax" (the realization of information structure) and "semantics" (information structure as an aspect of linguistic meaning). I presented several reflections on these theories, and argued why I opted for a Praguian perspective on information structure (though closely akin to Steedman's). Chapter 5 ended with a discussion of how information structure is represented in DGL.

It has often been observed that languages realize information structure differently, and that particular frameworks (like FGD or information packaging) are capable of *representing* this. In Chapter 6 I argued that we need to take this cross-linguistic perspective further, to a point where we can start thinking of how to *predict* when a language may avail itself of one means or another to indicate informativity – an argument dating back at least to (Mathesius, 1936). To this end, I first discussed how we may be able to predict when a language has rigid, mixed, or free word order. The resulting typology integrates (Steele, 1978) with (Sgall et al., 1986; Skalička and Sgall, 1994; Sgall, 1995a), confirming and refining their views. Subsequently, I proposed various hypotheses regarding the cross-linguistic realization of information structure. On the basis of a language's typological characterization, these hypotheses predict where to expect the (unmarked) canonical focus position, and when (and why) a language may make use of particular structural indications of informativity to realize information structure in more marked ways. Among the reasons for using a more marked realization I noted the possible projection of the information structure's focus, and thematic structure.

On the basis of hypotheses of Chapter 6, I elaborated a number of grammar architectures that model the basics of word order and tune as structural indications of informativity. First, in Chapter 7 I presented a model of word order as a structural indication of informativity. The Praguian concept of systemic ordering played important role in relating contextual boundness and word order variation, providing a useful level abstraction between the model describing structural indications of informativity on the one hand and the grammar architectures modeling the essentials of rigid, mixed and free word order in XV, VX and SVO languages on the other. Subsequently, I discussed in Chapter 8 Steedman's CCG-based theory of tune, and presented a model that overcomes some of the problems that can be noted for Steedman's proposal. Alike the model of word order as a structural indication of informativity, the tune model relates tune and contextual boundness on the basis of a (more abstract) structure that indicates whether elements occur in systemic ordering or not. The advantage for doing so was that we could provide a smooth integration between the architectures modeling how word order and tune realize information structure. We ended Chapter 8 with an illustration of how we can model the interaction of word order and tune in DGL.

Chapter 9 closed the second part with a discussion of how we can model the interpretation of information structure. Elaborating on earlier proposals like (Peregrin, 1995) or (Kruijff-Korbayová, 1998) I presented a dynamic interpretation of information structure, set in the context of a information structure-sensitive discourse representation theory. To illustrate the discourse theory, I modeled various issues in anaphoric binding, showing how information structure and dependency relations prove important to an adequate description of discourse interpretation.

RESULTS

To put it briefly, the dissertation argues how we can use a categorial-modal logical framework to model the basic principles underlying the Praguian conception of linguistic meaning: its structure in terms of dependency relations and information structure, its realization through word order and tune, and its importance to discourse interpretation.

Following functionalist views dating back to at least (Mathesius, 1936), the second part elaborated the principles for a *cross-linguistic* explanation of the realization of information structure. I restricted the account to the basic possibilities of word order and tune in their roles as structural indication of informativity. I gave an integration "from the ground up" of the typological description of word order into DGL, and presented various grammar architectures that modeled a cross-linguistic account of word order, tune and their principle roles in realizing information structure.

Although I necessarily focussed on cross-linguistic breadth rather than language-specific depth, various proposals were established in this part that not only answer many of the theses formulated in the Introduction to the dissertation, but which also hopefully provide a ground for further, more detailed accounts.

- **Ad Thesis 1**: Chapter 5 argued how we can integrate the representation of information structure at the level of linguistic meaning, and why the Praguian approach is preferable over other accounts of information structure.
- **Ad Theses 2, 6**: Particularly, Chapters 7 and 8 explained how we can relate indications of the *realization* of information structure to the underlying representation. The multidimensional signs of DGL are essential for this account to be compositional and monotonic. We focused primarily on word order and tune. Other indications, like morphological marking, can easily be included in a way described in Chapter 4.
- **Ad Thesis 3, 4, 5**: To be able to predict how variability in word order can realize information structure we need to be able to predict *when* a language *is able to* vary its word order - and to what extent. In Chapter 6 I presented various variation hypotheses that essentially related Steele's distinction of variability into rigid, mixed and free word order with the insights from Skalička's language typology. On the basis of these predictions, I presented several hypotheses predicting where to expect the canonical focus position in a language of a given type, and when and why it may avail itself of particular means to

realize information structure. Chapters 7 and 8 elaborated grammar architectures implementing the strategies predicted by the hypotheses of Chapter 6.

The proposals advanced in the second part significantly elaborate the account of information structure with respect to other theories like Vallduví's information packaging. Despite their small empirical basis, the hypotheses of Chapter 6 provide the means to make *predictions* about the realization of information structure, elaborating the intuitions in (Sgall et al., 1986). Furthermore, not only have I given grammar architectures that model these predictions from a cross-linguistic perspective, but I have also shown how accounts of structural indication of informativity like word order and tune can be smoothly integrated so as to be able to model their interaction. This goes well beyond the available formal accounts of information structure that I am aware of. Finally, I showed how a formalization can be given of the dynamic interpretation of information structure in a discourse representation theory that is sensitive to information structure and that includes Praguian notions like salience. On the formalization I pointed out how anaphoric binding can be modeled, and why dependency relations and information structure appear to be *necessary* to give an adequate account of discourse interpretation.

PART III

FINAL REMARKS

"No system would have ever been framed if people had been simply interested in knowing what is true, whatever it may be. What produces systems is the interest in maintaining against all comers that some favorite or inherited idea of ours is sufficient or right. A system may contain an account of many things which, in detail, are true enough; but as a system, covering infinite possibilities that neither our experience nor our logic can prejudge, it must be a work of imagination and a piece of human soliloquy. It may be expressive of human experience, it may be poetical; but how should any one who really coveted truth suppose that it was true?"

– George Santayana, *Winds of Doctrine* (1913)

CHAPTER 10

COMPARISONS AND CONCLUSIONS

The goal of this last chapter is to reflect on what we have finally arrived at: DGL on its own merits, how it delivers given the theses we set out with in the dissertation's Introduction, and how DGL compares to related frameworks. In the end, we provide a brief discussion of topics for further research.

> *This theory will make no pretension to being knowledge;*
> *but only to being a good guess, which we may strongly*
> *and confidently hope will be confirmed.*
> – Charles Sanders Peirce

10.1 CONCLUSIONS

The central thesis of this dissertation is that we can build a categorial-modal logical framework (Dependency Grammar Logic, DGL) that provides a basic model of various components of the Praguian conception of linguistic meaning. The components we have dealt with here are head/dependent-asymmetries, dependency relations and information structure, addressing their representation, realization, and interpretation. In that context, we have paid a fair amount of attention to cross-linguistic modeling. We have proposed basic hypotheses that predict cross-linguistic commonalities and differences in realizing dependency relations and information structure, and explained how these predictions can be integrated into multilingual grammar fragments that model these phenomena. With these architectures, DGL can build a representation of a sentence's linguistic meaning with its information structure in a compositional, monotonic way.

The first part of the dissertation described the foundations of DGL. DGL produces and represents linguistic meaning by coupling a resource-sensitive categorial proof theory to hybrid modal logic. A representation of a sentence's linguistic meaning is obtained from the analysis of its surface form, as in standard categorial grammar.

Chapter 2 explained how the basic hybrid logic $\mathcal{H}(@)$ can be used to provide a representation of linguistic meaning (without information structure, for the moment). Because from the Praguian viewpoint linguistic meaning is a relational structure, hybrid logic provides a natural setting to give a logical account of such structures. In this chapter, I restricted the discussion mostly to representational issues. I discussed how to represent dependency relations as modal relations $\langle\cdot\rangle$ and discourse referents as nominals. I also explained how to specify contextual reference at the level of linguistic meaning using the jump-operator (@) that enables us to make statements about relations between nominals (i.e. discourse referents). Besides discussing linguistic meaning, I also made a beginning with a proposal for how to use hybrid logic for providing a DRT-like theory of discourse.

Chapter 3 discusses linguistic meaning in more detail. I focused in this chapter on three important ingredients of (lexical and) linguistic meaning: predicate-valency structures, dependency relations, and aspectual categories. In brief, predicate-valency frames specify the meaning of a head, and by what dependency relations it has to be modified. A dependency relation determines how the meaning of a dependent contributes to the overall (linguistic) meaning of the head it modifies. Finally, a sentence's underlying aspectual category signifies the discoursive causal, temporal and spatial structure it reflects.

For many of the dependency relations I discussed in this chapter, I presented a hybrid logical specification of their semantic import. By a dependency relation's semantic import I mean the extra relations (or entailments) that can be projected: Thus, what do they assert about the meaning of the dependent itself, and in relation to the meaning of the head that is being modified? This is important. A dependency relation's semantic import may help determine a content verb's aspectual category, as I showed for cases involving causal or temporal dependency relations, or may have to be accommodated in the discourse context for the sentence's linguistic meaning to be coherent, as for example in the case of an attributive reading. The logical descriptions are couched in a many-sorted hybrid logic, formalizing (and elaborating on) Moens & Steedman's event nucleus (Steedman, 2000b), (**Thesis 7**). Combined with the ideas formulated in Chapter 2, and the discussion of predicate-valency structures in this chapter, a more precise picture of linguistic meaning and its representation arises. Representing dependency relations as modal operators makes a formula of the form *head* $\wedge \langle \rho_1 \rangle \delta_1 \wedge \cdots \wedge \langle \rho_n \rangle \delta_n$ a *relational* structure -which, in DGL, is a tree- rather than a function/argument-structure as we find it in more traditional approaches employing predicate logic. More specifically, the relational structure is a statement about nominals refering to identifiable states in some modal frame, the relations that are supposed to hold between these states, and what is said to hold at these states. The relational structure is understood to reflect a linguistic patterning found in the surface form.

In Chapter 4 I focused on the relation between linguistic meaning and surface form, in particular the realization of a linguistic meaning's dependency structure. To that end, I discussed how dependency relations can be related to morphological strategies that realize them. Because the relation is mediated by abstract morphological categories (like in Government & Binding's theory of case), the relation is not language-specific but cross-linguistic. In this way, DGL can provide a linking theory that overcomes the criticism that the interpretation of a wordform as a particular “role” is stipulated (Wechsler, 1995; Davis, 1996). Subsequently, I focused on how we can provide a logical calculus in which a sentence's linguistic meaning is built in a compositional, monotonic way as a reflection of the analysis of its surface form. I used a resource-sensitive categorial proof theory for the analysis of form, alike the Lambek-style calculi used in categorial type logic. However, rather than operating on type-logical terms to reflect semantics using a Curry-Howard style correspondence, the proof theory in DGL operates on hybrid logical terms. Using categories that indicate head/dependent asymmetries, and a formalization of morphological strategies using structural rules that can be used in a derivational analysis, I showed how we can obtain the kind of linguistic meaning representations discussed in earlier chapters.

The second part described information structure. The core questions I addressed were how to predict what strategies a language might employ to realize information structure, how to analyze a sentence in terms of structural indication of informativity and how such analysis (compositionally) leads to a representation of information structure in the sentence's linguistic meaning, and how to interpret these representations in a discourse model.

In Chapter 5 I discussed FGD's theory of topic-focus articulation, Vallduví's information packaging, and Steedman's Theme/Rheme-based theory.

All these theories have in common that they describe information structure in terms of its realization ("syntax") as well as its interpretation ("semantics"). In reflection on these theories, I noted several problems. I argued that information packaging is mistaken in its conflation of thematic structure and information structure, showing examples that it cannot satisfactorily explain. Furthermore, its characterization of the primary notions of ground and focus as partitions of a sentence's *surface form* leads to problems with recursivity, and appears at odds with the generally accepted idea of information structure being an aspect of linguistic meaning. Finally, its relation to a concrete grammar framework is underdeveloped. It is not clear how the GB architecture of (Vallduví, 1990) or HPSG (Engdahl and Vallduví, 1994) could be extended to explain word order, tune and their interaction as means to realize to information structure.

For FGD and CCG I observed that their notions of information structure are closely related. However, they differ substantially in their views of grammar. FGD adopts a transformational approach to explain how information structure acts as a parameter determining word order and intonation. CCG is a monostratal formalism in which sufrace form and underlying meaning (with information structure) are compositionally related. For FGD I noted that a transformational account cannot give a principled account of how different strategies (like tune, word order, morphology) can *interact* to realize information structure. CCG has been extended to cover tune and variability in word order, but I argued that CCG's Principle of Adjacency seems to necessitate a formal dissociation of the descriptions of word order and of information structure. This breaks with the general linguistic intuition of word order as a structural indication of informativity.

Like CCG, DGL is a monostratal, compositional approach. In DGL we operate on multidimensional signs that represent different levels of linguistic information, and there is no problem in letting different levels interact simultaneously. Like FGD, I consider information structure as an important factor in determining surface realization, and I argued how we can formalize that view in DGL's parametrized setting (using modes and structural rules). I ended the chapter with discussing how information structure is represented at the level of linguistic meaning in DGL. I considered a moderate form of recursivity of information structure, and explained how that enables us to cover complex examples involving double foci or embedded foci which e.g.

information packaging is unable to explain, , (**Thesis 1**).

Chapter 6 presents predictions about how information structure can be cross-linguistically realized through word order variation and tune. These predictions give rise to strategies characterizing a (typological) category of informativity, (**Thesis 3**). The first hypothesis, InfHyp1, predicts that the canonical focus position is the immediately preverbal position in OV languages, and in SVO constructions that have a clause-final verbal cluster. For VO languages and SVO constructions without verb-secondness, InfHyp1 predicts that the canonical focus position is post-verbal. We observed that sentence-finality may be effectuated, but that it is not defining. This enables us to relate the canonical focus position of (complex) Dutch and German clauses to the realization of information structure in OV languages like Hungarian or Turkish. The second hypothesis, InfHyp2, predicts how more marked realizations are realized. We noted that thematic structure and the possibility of focus projection may determine how information structure is to be realized, and that only through more marked constructions such realization can sometimes be achieved (e.g. to avoid ambiguity). InfHyp2 makes the following predictions about realizing the focus proper in a non-canonical focus position. As long as the construction cannot be understood to realize a focus in the canonical focus position and the non-canonical focus position is placed relative to the canonical focus position in keeping with the dominant linearization order, then word order can be used. Otherwise, an interaction between tune and word order is predicted. With respect to the hypotheses, we noted that there is a difference in the use of these strategies among languages with rigid, mixed and free word order, and that strategies are used to a relative rather than an absolute degree. The discussion in this chapter confirmed various of the principal hypotheses advanced in the Prague School of Linguistics, and most recently in FGD, about language typology (Skalička and Sgall, 1994; Sgall, 1995b) and the realization of information structure (Sgall et al., 1986; Hajičová, 1993). Even though we looked at a relatively small number of languages, the hypotheses have been formulated against data that is typologically more diverse than is usually considered in the literature.

Chapters 7 and 8 show how these strategies can be modeled in grammar architectures, (**Theses 4, 5**). Chapter 7 provides architectures modeling word order as a structural indication of informativity. In this chapter I started with a discussion of various approaches to modeling word order in a categorial grammar - CCG, MCCG, Set-CCG, and categorial type logic. I elaborated on why we choose for viewing adjacency as a parameter rather than a principle. The "principle"-view yields (in contemporary formulations of CCG) various technical consequences that are at odds with our linguistic intuitions, like the dissociation between the explanations of word order and information structure in MCCG. The "parameter"-view enables us to consider information structure as a primary factor (parameter) determining word order. I presented grammar architectures that formalized the basic aspects of rigid, mixed and free word order, including complex phenomena like (discontinuous) cross-serial dependencies and nested dependencies. Subsequently, I extended these architectures with models of how word order principally acts as a structural indication of informativity in OV, VO, and SVO, as far as covered by the informativity hypotheses of Chapter 6. The approach I adopted was to relate the syntactic modes to modes that just show whether or not systemic ordering is adhered to, after (Sgall et al., 1986). This provides us not only with a very general description of the relation between word order and information structure. It also enables us to describe the interaction between tune and word order in a straightforward way, as explained in Chapter 8.

In Chapter 8, I first discussed Steedman's theory integrating tune into a CCG of English. I criticized Steedman's use of empty strings to model boundary tones, and presented an abstract model of Steedman's account of tune that shows how we can model boundary tones as complex feature labels. A further distinction is that the model interprets tunes on wordgroups relative to whether these words appear in systemic ordering. This perspective extends the Praguian view on the relation between word order and systemic ordering to tune. The advantage of doing so is that the interaction between tune and word order can be (formally) described in terms of how tunes should be interpreted relative to systemically and non-systemically ordered wordgroups. We ended the chapter with a brief discussion of such a description, and showed an example involving the interaction between tune and mixed non-systemically ordered realizations of dependents in an SVO language type.

Using the architectures developed in Chapters 7 and 8 architectures, DGL can build a representation of a sentence's linguistic meaning with its information structure in a compositional, monotonic way, (**Theses 2, 6**). In Chapter 9 *interpretation* of information structure, and we give a logical characterization of contextual boundness, topic and focus in terms of *dynamic interpretation* on a discourse model. The logical characterization extends our earlier discussions in Chapter 2. It elaborates the earlier dynamic proposals in (Peregrin, 1995) and (Kruijff-Korbayová, 1998). Like (Kruijff-Korbayová, 1998) we consider interpretation in the context of an information structure-sensitive discourse theory, and we provide an account that is intensional rather than extensional (Peregrin, 1995).[1] We also showed how a Praguian notion of salience can be formally integrated into our proposal. We rounded off Chapter 9 with a discussion of contextual reference resolution, showing how we can model the binding of normal pronouns, reflexive pronouns and exempt anaphors – for which the fine-grained, dependency-based characterizations of linguistic meaning proved convenient if not indispensable.

To recapitulate, the dissertation makes the following contributions:

- A logical description of the semantic import of dependency relations and of their interaction with a sentence's underlying causal, temporal and spatial structure (Chapter 3).
- A logical formalization of, and extension to, Moens and Steedman's theory of tense and aspect (Chapter 3).
- A logical, dependency grammar-based framework that relates a resource-sensitive categorial proof theory to a low-complexity hybrid modal logic using a (linguistically motivated) Curry-Howard correspondence to model the interface between form and linguistic meaning (Chapter 4).
- A preliminary linguistic-typological explanation of when languages may display variability in word order, how and when this variability may be used as a structural indications of informativity, and how and when structural indication of informativity like word order and tune may interact (Chapters 6 & 6).
- A cross-linguistic logico-grammatical architecture modelling mentioned explanation of the realization of information structure, including a basic model of dominant word order, basic variability in word order across VX, XV, and

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[1] Note that there exist earlier intensional characterizations, like (Materna and Sgall, 1980) or (Materna et al., 1987). The difference is that here a discourse theory plays a more prominent role.

SVO languages, a logical reformulation of (part of) Steedman's grammar of tune, possible interactions between tune and word order – all considered as reflections of, and thus related to, information structure as represented at the level of linguistic meaning (Chapters 7 & 8).

- A logical reformulation of (part of) Kruijff-Korbayová's information structure-sensitive discourse theory (TF-DRT), including a discussion of the linguistic meaning/discourse-interface (Chapter 9).

10.2 COMPARISONS TO RELATED FRAMEWORKS

How does DGL compare to related frameworks, like type-logical grammar, Tree-Adjoining Grammar, HPSG - or dependency grammar for that matter? Below I presented some brief comparisons.

Let me start with type-logical grammar. Type-logical grammar relates categories to types of an intensional type theory using a mapping that makes *semantic* argument structure isomorphic with *syntactic* argument structure, cf. (Oehrle, 1994) and (Moortgat, 1997) for specifications of this mapping. As I already commented in Chapter 4, there are various linguistic arguments why this mapping should not be an isomorphism. For example, expletive pronouns are semantically void but may be syntactically required, and relational nouns have a semantically obligatory argument which has no syntactic reflection. Furthermore, from the viewpoint of information structure and the implications it has for a strict Carnapian division between "semantics" and "pragmatics" (Peregrin, 1999), it remains to be seen how far a close relation to the original tenets of Montague Grammar like in (Morrill, 1994) should be maintained, cf. also (Hajičová et al., 1998) and the Introduction to this dissertation.

An obvious but significant technical as well as conceptual difference between type-logical grammar and DGL is of course that the latter is dependency-based. The representation of a sentence's linguistic meaning is a dependency structure including information structure – in which, for example, a locative "sentential adjunct" is still modelled as a proper dependent of the verb, and does not end up as a predication over the verbal predicate and its arguments. Furthermore, explanations of prosodic, morphological and syntactic form are mostly conceived of in terms of how they realize underlying meaning. Both DGL and categorial grammar in general share the view that the only proper level of representation in categorial grammar is that of meaning (Moortgat, 1988; Morrill, 1994; Steedman, 1996). However, DGL follows the Prague School of Linguistics in using the structure of (linguistic) meaning as the primary motivation for explaining surface form – from which also notions like "flexible constituency" and head/dependent-asymmetries are a natural consequence. Furthermore, the use of a sorted modal logic like hybrid logic (rather than intensional type logic) makes it easier to create perspicuous yet detailed representations of linguistic meaning, and deal with issues like the semantic import of dependency relations.

Finally, there is a close relation between DGL and discourse interpretation without either having to assume indexation to resolve contextual reference (Van Eijck and Kamp, 1997) or taking the proof-theoretic perspective into a realm where its application seems less unintuitive as we are focusing on model-theoretic interpretation (Jäger, to appear).

A few comments are in place with regard to the relation between CCG (Steedman, 2000a; Steedman, 2000c) and DGL. Although both share a common categorial base, DGL stands in the logical (Lambek) tradition whereas CCG represents the combinatory tradition of categorial grammar. Within the logical tradition, CCG has been criticized for providing a non-logical theory of syntax, "in the sense of being the reflection of an interpretation of category formulas but, as in e.g. HPSG, DCG, and CF-PSG, a deductive system receiving definition in terms of non-logical axioms and rules." (Morrill, 1994)(p.232). In the logical tradition, variation in phenomena is modelled as variation in logical expressivity, not by adjusting the basic calculus of existing operators. (Kruijff and Baldridge, 2000) reflects on such criticisms, and shows how we can construct a reinterpretation of CCG in terms of categorial type logic. Hence, the criticism on CCG can be overcome – as can the criticism, levelled by (Steedman, 1996), that any approach based on categorial type logic unavoidably leads to a collapse to the Lambek-Van Benthem calculus LP. It is true that an unrestricted version of categorial type logic might precipitate such a collapse (Moortgat, 1988) and makes the framework Turing-complete (Carpenter, 1995). Yet, (Kruijff and Baldridge, 2000) shows that the power of categorial type logic can be harnessed and still lead to an interesting generative strength (mild-context sensitivity) and a similar computational complexity as proven for CCG (Vijayashanker and Weir, 1990). On a more linguistically oriented note, DGL differs from CCG in that DGL provides a model-theoretic interpretation of information structure with respect to a discourse model. CCG presents the meaning of information structure using alternative sets that are -as (Steedman, 2000a)(p.658) points out- used for reasons of exposition rather than providing a proper interpretation. In fact, more powerful means than the existentially flavored alternative sets are needed to deal properly with interpretation of information structure in a discourse context (Peregrin, 1995; Kruijff-Korbayová, 1998; Hajičová et al., 1998). DGL does provide these means - witness Chapter 9.

Moreover, we noted in Chapter 5 potential problems with CCG's Principle of Adjacency, and the dissociation of the explanations of word order and of information structure it necessitates in MCCG. In DGL we do not separate the account of word order from information structure, but show how variation in word order can be modeled as a structural indication of informativity leading to a representation of a linguistic meaning's information structure in a compositional way.

Unlike DGL, and the categorial type logic framework it builds on, mainstream HPSG has no proper logical foundation (King, 1989; King, 1999), contrary to the suggestions of (Pollard and Sag, 1993). This creates sometimes less than elegant expositions. On the one hand, its feature 'logic' may necessitate overly complex encodings - witness the specification of "she" in (Pollard and Sag, 1993)(pp.19-20). As (Heylen, 1999) argues, categorial type logic already provides the necessary tools to achieve the same goals, albeit in a cleaner fashion. At the same time, HPSG appears to create the possibility for a greater freedom in which information from different levels may be understood to interact. This is not necessarily always desirable. In DGL's account of information structure, we keep separated the realization of information structure, its representation, and its interpretation. On the other hand, more detailed expositions of information packaging in HPSG, like (Alexopoulou, 1999; Alexopoulou and Kolliakou, to appear; Kolliakou, 1998), information from different linguistic as well as extra-linguistic levels (like CONTEXT) is freely used to explain aspects of form.

Here, I avoid an in-depth discussion of word order in HPSG. This would only be possible in the context of a proper exposition of the various mechanisms that have been proposed in work by e.g. Uszkoreit, Reape, Kathol, and Penn. Naturally, HPSG has to develop relatively elaborate accounts of word order in order to overcome its phrase-structure heritage – unlike DGL, which employs no notions of "phrase" or "constituent" for that matter. For an HPSG-account that appears to have affinity with the formal account of word order I have given here, the interested reader is refered to (Penn, 1999). Moreover, a detailed comparison between a dependency grammar-based account of word order and HPSG proposals can be found in (Bröker, 1997).

In brief, DGL compares to dependency grammar as follows. First of all, we should remark that there is not a singular understanding of what constitutes "dependency grammar". There exists a large number of proposals, like Word Grammar (Hudson, 1984), Meaning-Text Model (Mel'čuk, 1988), Case-Based Semantics (Fillmore, 1968), and of course Functional Generative Description (Sgall et al., 1986), to name but a few. I already refered earlier to Case-Based Semantics and the criticism levelled against that approach in (Panevová, 1974) and (Sgall et al., 1986). The dependency relations ("cases") discerned in Case-Based Semantics are not motivated on the basis of clearly formulated linguistic criteria, like in FGD, but appear to be subjective. Conversely, Word Grammar is not subject to that problem. Its notion of dependency consists in a distinction between heads and dependents but not in there being any additional differentiation between dependency relations. Of course this leads then to other problems, since I have argued here that such differentiation is necessary to be able explain various phenomena like particular kinds of aspectual change, or exempt anaphora. Moreover, outside FGD none of the dependency grammar frameworks take information structure into account. Finally, I broadly agree with (Bröker, 1997)(p.194) that "[d]ie DG hat den trend zur mathematischen Fundierung (noch) nicht vollzogen, der in fast allen modernen PSGen zu beobachten ist."[2] DGL appears to be the furthest-reaching contemporary formal account of dependency grammar.

10.3 Topics for further research

There are many issues that have been left unexplored in this dissertation. All the issues we have dealt with in this dissertation could be dealt with in much more detail than is possible in the space of –roughly– 370 pages. For example, the entire typological account deserves more investigation. Most

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[2] Lit. "Dependency grammar has not (yet) performed the trend to mathematical foundation that is observable in all contemporary phrase-structure grammars."

likely the hypotheses concerning information structure realization that I presented in Chapter 6 need refinement. This can only be done in an empirical study of a scale larger than suitable for a dissertation, but hopefully the approach taken here provides a good basis for such a study.

Furthermore, a lot more can be said about the use of sorts in hybrid logic to model meaning. Here, I have only paid attention to sorts involved in temporal and spatial structures. Naturally, there is a question of how to deal with objects and properties, which I entirely avoided here. Similarly, but more from the perspective of discourse theory, one could investigate discourse relations and their relation to information structure. Within the Prague School of Linguistics various authors have worked on these issues (notably, Daneš), and (Kruijff-Korbayová, 1998) briefly touches upon the issue in the context of TF-DRT. See also our earlier work in (Kruijff-Korbayová and Kruijff, 1996; Kruijff and Schaake, 1996).

At least the following seem addressable in the framework provided by DGL. Hajičová & Sgall present in (Hajičová et al., 1998) a discussion of focalizers from the viewpoint of Praguian topic-focus articulation. It would be interesting to elaborate DGL's formalization of information structure to cover focalizers as well. Also, another issue where the distinction of dependency relations and information structure seems important, is the modelling of the behavior of polyselective quantifiers like "already". It appears that a polyselective quantifier selects particular types of dependents as arguments, and that the scope of its selection depends on information structure.[3]

Finally, as I pointed out already in the Summary to Part I, I paid little or no attention to computational aspects in this dissertation. This is not to say that we should avoid these issues, or that we expect them to be unfavorable for DGL. On the contrary, given (Kruijff and Baldridge, 2000) there is good reason to expect that the generative strength of DGL is around mild-context sensitivity, and that we have a polynomial time worst-case complexity for parsing with the architectures. The results in (Hoffman, 1995a) strenghten this belief, as does the obvious possibility of extending the simulation in (Kruijff and Baldridge, 2000) to Set-CCG (Baldridge, 1999).

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[3] These points arose in personal discussion with Stanley Peters, and seem to confirm some of the more general intuitions about quantifiers advanced in (Sgall et al., 1986; Hajičová et al., 1998).

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